COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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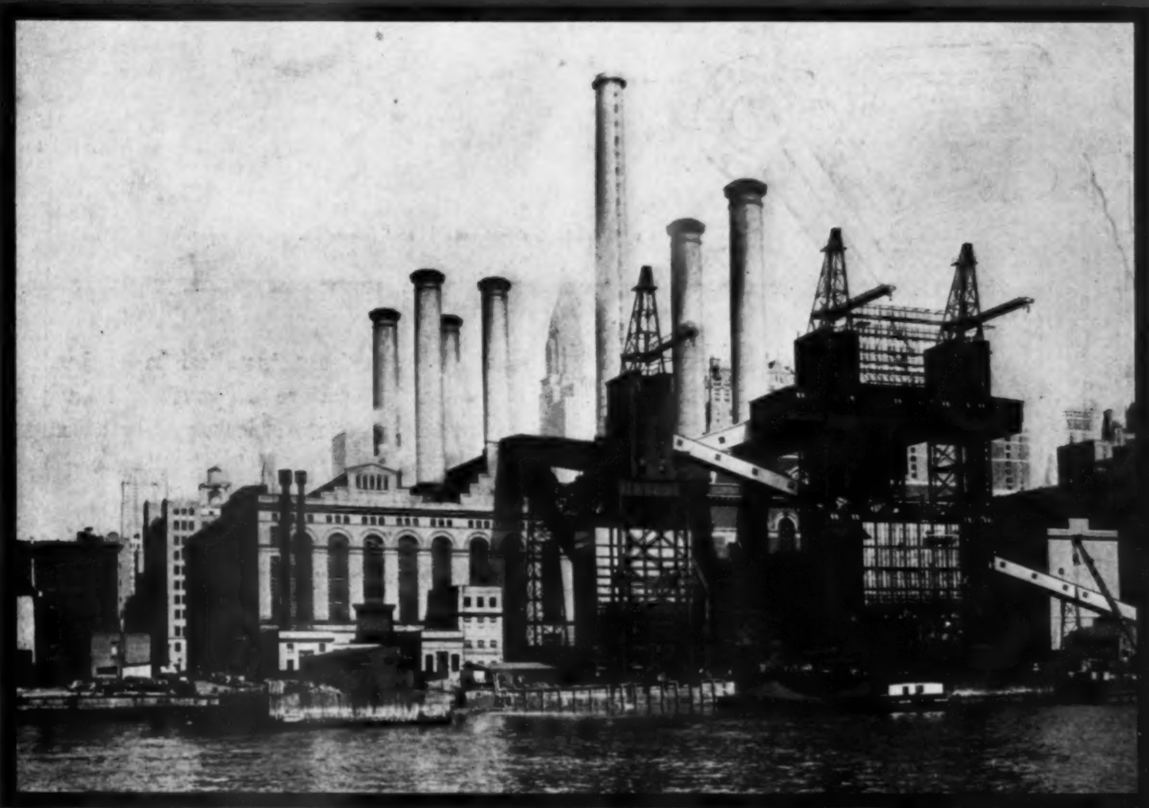

Waterside Station, New York

Steam Generating Equipment at Waterside Station, New York

The Guffey Act, the Coal Market and the Industrial Consumer

Steam Contamination—I

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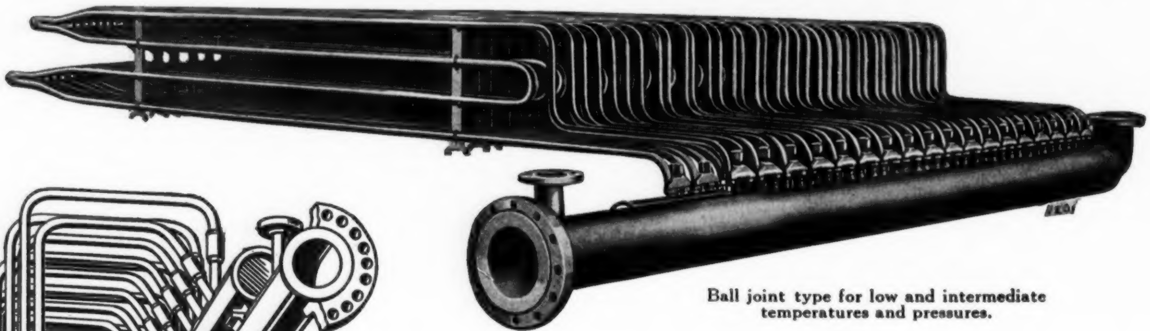
for any SUPERHEAT requirement



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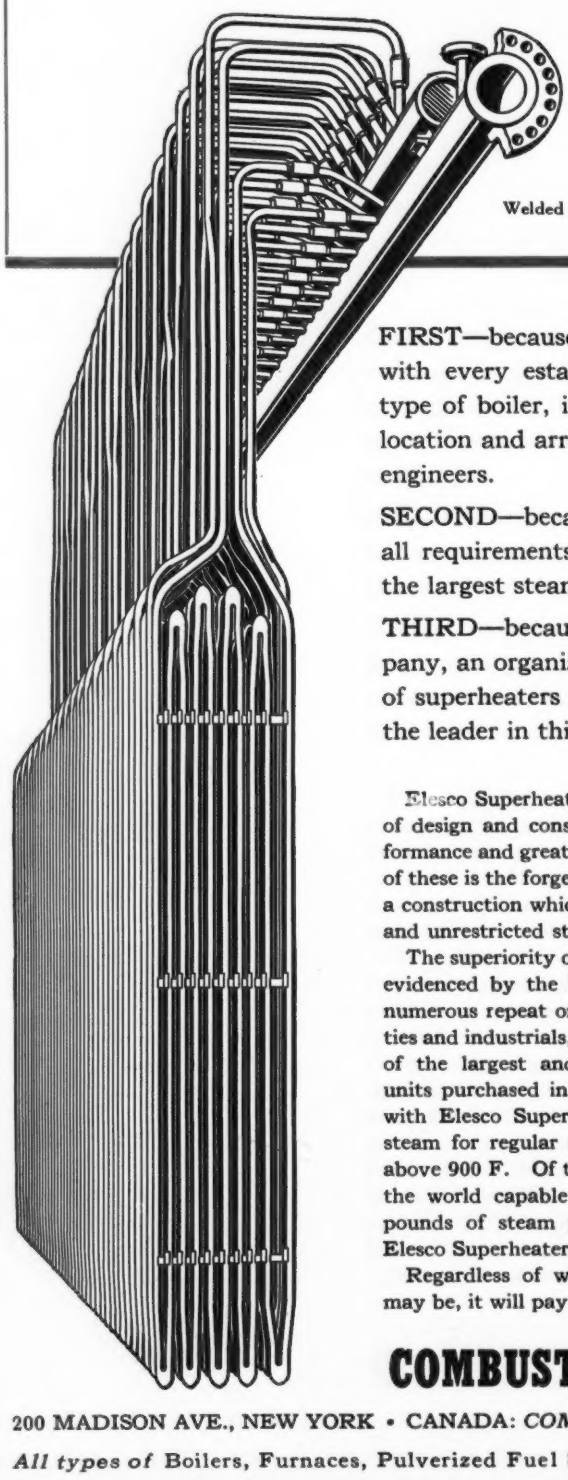

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THIRD—because Elesco Superheaters are made by The Superheater Company, an organization which has specialized in the design and manufacture of superheaters for many years and which is internationally recognized as the leader in this field.

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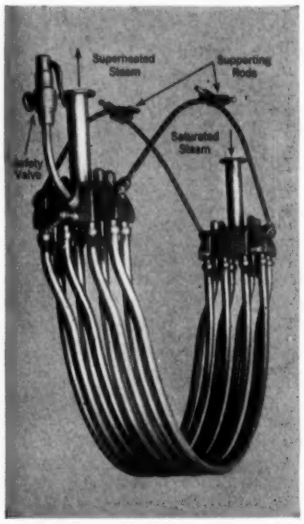

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME NINE NUMBER THREE

CONTENTS

FOR SEPTEMBER 1937

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

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EDITORIAL

The Bituminous Coal Act

Most readers of COMBUSTION will be affected directly or indirectly by the administration of the Bituminous Coal Act of 1937, commonly referred to as the Guffey-Vinson Act, the price-fixing features of which will go into effect this Fall. Its influence is far-reaching, not only upon mine labor, coal producers and marketing agencies, but upon all users of bituminous coal, in that they are almost certain to pay a sharp advance in price and in many cases will find it necessary to readjust their procedure of coal selection. Power plant designers will likewise be compelled to take cognizance of the new price levels and revised differentials in selecting equipment that will produce the most favorable commercial efficiency.

Central stations and certain manufacturing industries, in which fuel enters largely into the cost of the manufactured product, will be particularly affected, for, under the terms of the Act, the purchaser of large tonnages will enjoy no price advantage over the one who purchases a carload. Already burdened with high taxes and faced with both government competition and demands for still lower electric rates, the central station, unlike some other industries, will find it difficult to pass on to the consumer the increased cost of its fuel.

The Act carries and extends many features of the Coal Code that existed under the NRA, and is an attempt not only to improve labor conditions but to stabilize the coal industry, both of which suffered keenly during the buyer's market of depression years. Through the service of marketing agencies it should be possible to bring about a better balance between the demand for different grades and sizes of coal, some of which were previously sold below the actual cost of production to keep them moving. Inasmuch as the minimum selling price prescribed by the Commission is to be determined on the basis of the average cost of production in a given district, the more efficient producers should profit accordingly and there will be provided an incentive for the less efficient mines to modernize their methods.

To one who has some conception of the infinite intricacies of the coal marketing problem, involving innumerable grades of coal from thousands of mines, many supplying the same competitive markets, the task of regimenting the industry seems almost insurmountable. This attempt at rigid control may prove feasible in a rising market such as is likely to obtain for the next two or three years, but there is some doubt as to whether it can be sustained without considerable modification in a falling market, when the economic forces of supply and demand become most potent.

Meanwhile, the Act, in its present form, is the law and plans for its administration and enforcement are rapidly taking form. It therefore behooves the coal user now to give serious consideration as to how he can best be served under its provisions. The article by Mr. Gould in this issue provides some background for his guidance.

Increased Electrical Output

The unprecedented total of nearly one hundred and eighteen billion kilowatt-hours of electricity was produced for public use in the United States during the twelve months ending July 31, 1937, according to a report just released by the Federal Power Commission. This represents an increase of eleven billion kilowatt-hours over the output for the preceding twelve-month period, and is slightly in excess of the figures issued by the Edison Electric Institute, which makes deductions for certain plants not considered as strictly utility enterprises.

It is not surprising to note that Chairman McNinch of the Commission attributes the increase to a widespread reduction in electric rates. While this has undoubtedly been a factor, its influence is confined largely to domestic consumption, the increase in which has been only one-fourth to one-fifth that among large industrial users. To the latter, electric rates are important in deciding whether energy shall be purchased or privately generated, but the amount used is determined by the production activity. The increased index of production, for the period covered, among those industries requiring large amounts of power, will be found to account for the major portion of the electrical output, despite the contention of Mr. McNinch.

Waterside

Of the numerous "topping" installations now under construction, few compare in magnitude with that of Waterside in New York, the modernization program of which calls for eight high-pressure steam generating units and four turbine-generators of over 200,000 kilowatts combined capacity. Half of this capacity is now nearing completion or is on order.

In continuous operation for the past thirty-six and thirty-one years, respectively, Waterside Stations Nos. 1 and 2 have contributed their full share of the ever-growing electrical load in New York. Although prime movers were replaced or added from time to time during this period, until the present revamping program there was no change in the steam conditions nor in the boilers except to substitute stokers for hand firing.

The article by Mr. Orrok in this issue is an interesting account of the early history of these stations and when read in conjunction with the description of the superimposed installation by Messrs. Johnson and Kelting, it affords a striking example of the advances in steam generating practice during the last thirty years. Outstanding in this connection is the replacement, in the same building space, of ninety-six low-pressure boilers by eight modern high-pressure units. It is expected that the new high-pressure units will decrease the station heat rate to about 11,500 British thermal units per net kilowatt-hour.

Steam Generating Equipment at Waterside Station, New York

By H. A. JOHNSON, Division Engineer
Consolidated Edison Company
and
C. A. KELTING, Ass't Division Engineer
Consolidated Edison Company

The rebuilding program provides for the replacement of ninety-two 650-hp low-pressure boilers and ten turbine-generators in Waterside No. 2 by eight large 1400-lb steam-generating units and four 53,000-kw high-pressure turbine-generators which will exhaust at 200 lb to existing machines in Waterside No. 1. Four of these new boilers and two turbine-generators are nearing completion or on order. The article deals largely with details of the steam-generating equipment, structural changes and with the piping.

ABOUT forty years ago, the engineers of a predecessor of The Consolidated Edison Company were instructed to select for the site of a large central station a waterfront location which would be nearest the load center of the system. Their selection resulted in the original Waterside Station and that their work was done well is evidenced by the fact that, while during the intervening years nearly everything else in New York City has changed, Waterside is still in the center of the load and in the section of the city where the load is growing most rapidly.

This station occupies two city blocks between 38th and 40th Streets, fronting on the East River. The two sections are divided by East 39th Street but are interconnected by numerous steam, water and electric lines to such an extent that they may now be regarded as one station.

The earlier section, Waterside No. 1, was originally designed for sixteen 3500-kw reciprocating engines and fifty-six 650-hp, 200-lb, saturated-steam boilers, fired partly by Roney stokers and partly by hand. The original engines, eleven of which were installed, have been removed and replaced by turbines. The boilers have been equipped with superheaters and underfeed stokers. The second section, Waterside No. 2, was built about five years later. It was designed for ten 8000-kw turbine-generators and ninety-six 200-lb hand-fired boilers equipped with superheaters. The only material change made in this section of the station, to the inception of the present rebuilding program, has been the replacement of two of the original 8000-kw turbine-generators by larger units operating under the original steam conditions and the substitution of underfeed stokers for hand-fired grates on all of the boilers.

Rebuilding Program

The rebuilding program now under way will eventually involve the retirement of ten vertical turbine-generators of 114,000-kw aggregate capacity, ninety-two remaining 650-hp boilers and all their auxiliary equipment in Waterside No. 2, including four 300-ft stacks. In the space left vacant by the removal of this generating equipment will be located four 53,000-kw, 1200-lb, 900-F, 60-cycle superposed turbine-generators,[1] exhausting to the existing 200-lb steam mains supplying the turbines in Waterside No. 1; and also one condensing unit to operate at 200 lb, 500 F. Eight 500,000-lb per hr, 1400-lb 900 F pulverized-fuel-fired steam generating units will occupy the entire boiler house originally devoted to ninety-six low-pressure boilers.

Structural Changes

Many interesting problems are presented in the adaptation of an old structure for a type of equipment radically different from that for which it was designed. This is particularly the case in the boiler room which was designed for 650-hp boilers on two floors with column centers of 15 ft 6 in. The problem of replacing these small boilers with units having fifteen times their individual capacity was solved by removing two columns for each boiler and extending the boilers from the basement to the third floor level. By this means a clear space was obtained approximately 30 ft wide by 88 ft high. The size of the boilers was for practical purposes determined by the amount of capacity which would go into this space, each of the new boilers occupying a space which formerly contained eight of the smaller units, the center bay being occupied by feedwater heaters and other auxiliary equipments.

Other important changes were the removal of three of the five original coal bunkers and the replacing of the two existing stacks by a new one which serves the first four high-pressure boilers. In fixing the height of the stack consideration was given to the existence of tall buildings in the immediate neighborhood and the top of the stack was so located as to discharge the products of combustion at an elevation above that of any building within a quarter of a mile. The new stack is 31 ft in diameter at the base and 21 ft at the top, rising 300 ft above the boiler

[1] Two of the high-pressure boilers and one Westinghouse turbine-generator are now nearing completion and a second group of two boilers and one G. E. turbine-generator of similar capacity is on order. The first of these machines was described in COMBUSTION of May 1937—EDITOR

house roof, with a top elevation of 450 ft above street level.

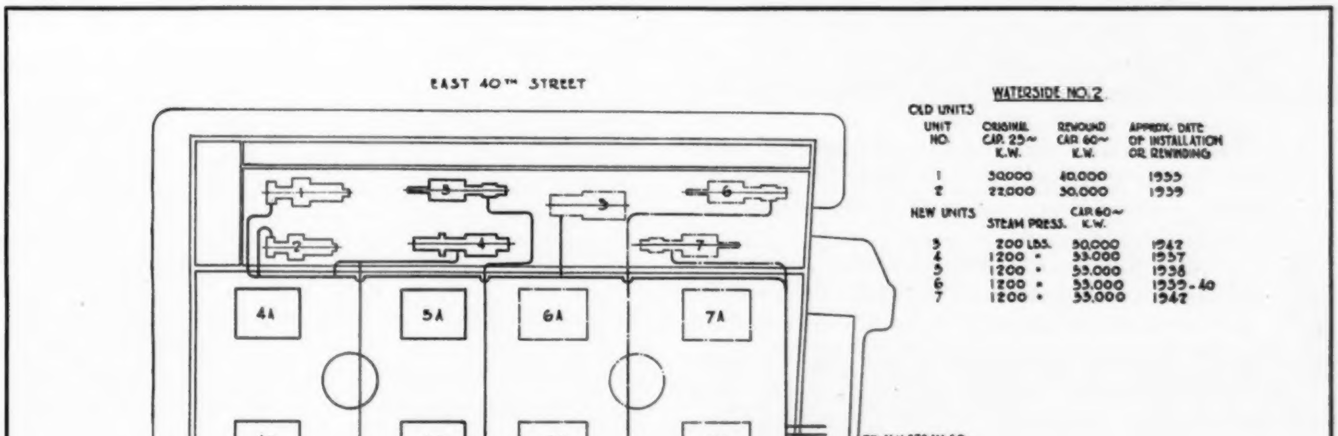
The stack is constructed of steel plates $^3/_4$ in. thick at the base, reduced in $^1/_{16}$-in. increments to $^7/_{16}$ in. at the top. The lining is of 4-in. brick with 1-in. cement mortar between the stack and the brick. The stack is designed for a wind load of 20 lb per sq ft of projected area and stresses in both compression and tension have been limited to reasonably low values. An allowance was made in all calculations of $^1/_8$ in. in thickness for corrosion. The 1100 tons of the completed stack are supported by a network of intercepting beams and girders framed into four short new columns. The load from each of these columns is distributed at a lower level over four existing columns. A second such stack, now being erected, will be required for the second group of four boilers.

In the turbine room the structural problem was comparatively simple. The removal of eight existing turbines leaves a space free of serious interferences, with the exception of the footings for the turbine foundations. These were complicated by the existence of five circulating-water and exhaust tunnels in the mat occupying over half of the turbine room floor area. In order to keep these tunnels in operation for the service of the two low-pressure units which were not removed, it was necessary to bore, with a core-boring machine, 3-ft holes down to solid rock under each of the main turbine foundation columns.

Coal and Ash Handling

Two bunkers are being retained for use with the new boilers and little change has been made to the conveyor belt system, except to install magnetic pulleys ahead of the bunkers. Each bunker originally served eighteen downspouts and one of the problems in connection with supplying coal to the eight pulverizers of four new boilers has been to provide a means for complete emptying of any portion of the bunker. Two "run around" Redler conveyors immediately below the bunker make possible feeding any of the mills from any part of the bunker. These conveyors will be operated only to the extent necessary to prevent bunker fires. Richardson automatic weigh scales are provided in the coal downtake to each mill.

Eventually the slag tapped from the furnaces will be transported hydraulically to a pit on the dock, but the installation of a hydraulic system is impracticable until the East River Drive construction is completed. In the meantime, duplicate de-watering bucket elevators are provided under each boiler to deliver the slag to a hopper from which point it is transported by the old car and skip



Layout for revamped Waterside Stations

hoist system, along with stoker ash from the low-pressure boilers still in operation, to an ash hopper on the dock.

The fly ash from the Cottrell precipitators and flues is transported by a pneumatic conveyor ("Nureyor" system) to two elevated separator tanks from which it passes to an ash hopper on the dock, thence through a tempering mixer, with enough water added to prevent a dust nuisance, into a bottom-dumping scow which takes it out to sea. It is desirable to keep slag separate from fly ash since the slag can be given away while the disposal cost of fly ash is about 50 cents per cubic yard.

Smoke and Fly Ash Elimination

A modern residential development of tall apartment buildings has nearly surrounded the Waterside Station, replacing a group of cheap tenement houses. This change in the character of the neighborhood has made cleanliness of stack discharge a matter of paramount importance. This problem has received careful study and several specific provisions have been made, based on the best available equipment and bringing to bear all design information within present knowledge. These are:

1. Furnace design has been liberal so that a maximum heat release of 30,000 Btu per cu ft will allow smokeless combustion over the full range of load.
2. To prevent smoke when starting a cold furnace, arrangements have been made for burning gas until the boiler is on the line.
3. The continuous slag tap furnace will retain a considerable proportion of the ash and reduce the duty required of the precipitators.
4. Three Cottrell electrostatic precipitator units have been installed on each boiler. These are three sections deep and have a guaranteed efficiency of 95 per cent.
5. The flue gas, as near smokeless and dustless as possible, is kept from entering windows of adjoining apartment buildings by unusually tall stacks.

From the foregoing, it is seen that the entire boiler plant design has been controlled so as to make Waterside Station as good a neighbor as is physically possible.

Boilers and Furnaces

The steam-generating units, each of 500,000 lb per hr rated capacity at 1350-lb drum pressure and 900 F total steam temperature, are of the Combustion Engineering single-drum sectional-header type. The drum of each is 60 in. inside diameter and 30 ft 7 in. long with a plate thickness of $4^3/_4$ in. It is rolled from two sheets and has two longitudinally welded seams. The inside of the drum is sand-blasted for coating with Apexior. The six-tube high, 7000-sq ft sectional-header part of the boiler represents a very small proportion of the total heating surface of the unit and will absorb less than 10 per cent of the heat input. The fin-tube furnace walls of 7548 sq ft absorb about 55 per cent of the heat input, the superheater over 24 per cent and the economizer the remainder. The width of furnace is 24 ft 7 in. and the volume 20,300 cu ft. It is of the continuous-slagging type.

The superheater, located immediately above the boiler tubes, is of the "Elesco" type and is constructed in two sections of 200 six-loop elements arranged in upper and lower banks. The tubing of the upper banks is 2 in. diameter hot-finished carbon steel. The bottom section, 12 tubes deep, consists of five tubes of hot-finished carbon steel, five tubes of carbon steel with 0.5 per cent molybdenum and two tubes of hot-finished tubing containing 0.5 per cent each of chromium and titanium. The superheating surface is 14,000 sq ft.

The economizer of each unit is of the "Elesco" return-bend, fin-tube construction, located within the boiler casing, the gases passing downward and out through the back of the boiler at a point just above the boiler tubes. It has 680 tubes 24 ft long, 2 in. outside diameter and a total heating surface of 18,850 sq ft.

Superheater and economizer are located alongside each other with a vertical passage between, controlled by a damper for regulating gas flow over the superheater tubes. This damper will automatically maintain the steam temperature at any desired point between 850 F and 900 F from three-quarter load to full load. Provision for reducing the superheat to 850 F is necessary to prevent excessive exhaust temperature from the high-pressure turbine when the unit is operating at partial loads and exhausting into cast-iron casings of the low-pressure turbines.

The two Ljungstrom air heaters, of 65,400 sq ft total surface for each boiler, afford a very compact arrangement, inasmuch as they are located directly in front of the boiler, below the forced- and induced-draft fans (see cross-section); the preheated-air and hot-flue ducts are therefore quite short. They are driven by 3-phase G. E. squirrel-cage induction motors.

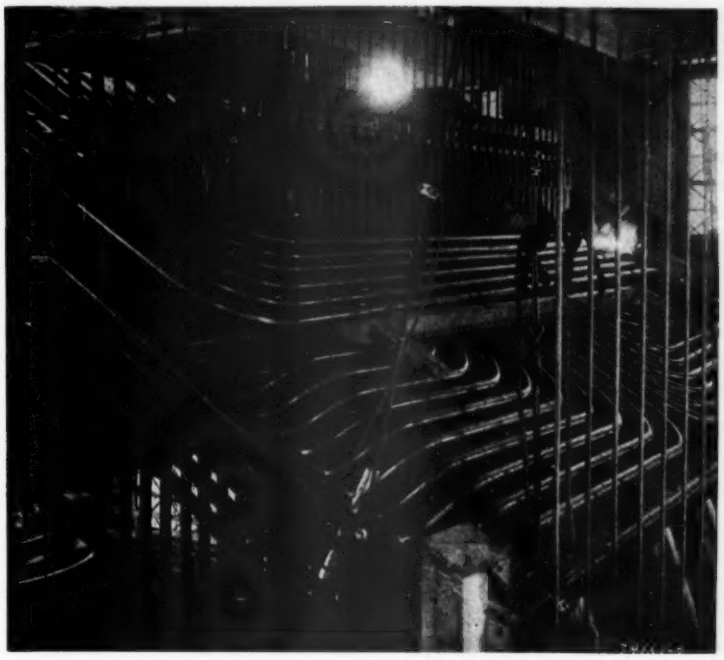
With either mill or both in operation, tangential firing from all four corners is provided by duplex burners. Gas burners are installed having sufficient capacity to put the boilers on the line without the use of coal. This provision makes possible heating up the boilers as slowly as is required.

Forced- and Induced-Draft Fans

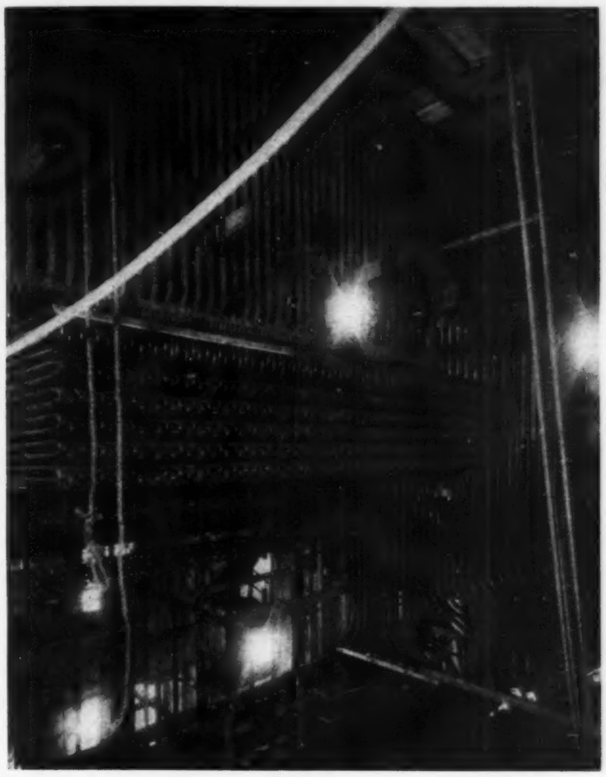
Two Sturtevant vane-controlled forced- and induced-draft fans are provided per boiler. One forced- and one induced-draft fan wheel are mounted on a single shaft and driven at constant speed by a single induction motor. The electrical supply for the two induction motors serving each boiler is so arranged that neither fan shaft can run alone, so that the two pairs of fans operate as a single unit. The vanes at the inlets of the two induced-draft fans are mechanically interconnected and regulation of the air flow through the boiler is by means of a single operating lever. Similarly, the forced-draft fan vanes are interconnected so that the furnace draft is also controlled at a single point.

Electrostatic Precipitation

Cottrell electrostatic precipitators are located in the space made available by removing one of the existing alternate coal bunkers. More than adequate in size, each precipitator serving a boiler is three sections wide by three sections deep. Any precipitator section may be taken out of service for scraping the plates, by the use of air-operated dampers which temporarily increase the gas velocity through the remaining two sections by 50 per cent. Unusual depth is provided to secure the highest possible efficiency, the three sections representing half again as long gas travel as has previously been considered good practice. Dust in the nine hoppers of each



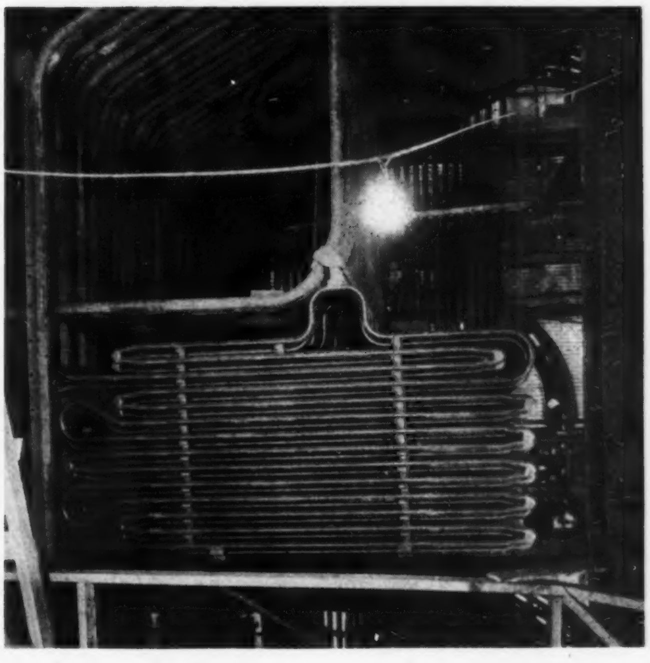
Above—Roof of boiler No. 4B at elevation 78 ft 6 in.



Above—End view of superheater elements, supports and lower header

Below—Side view of superheater elements and roof tubes with side wall in background

Above—Northeast water wall of boiler No. 4A

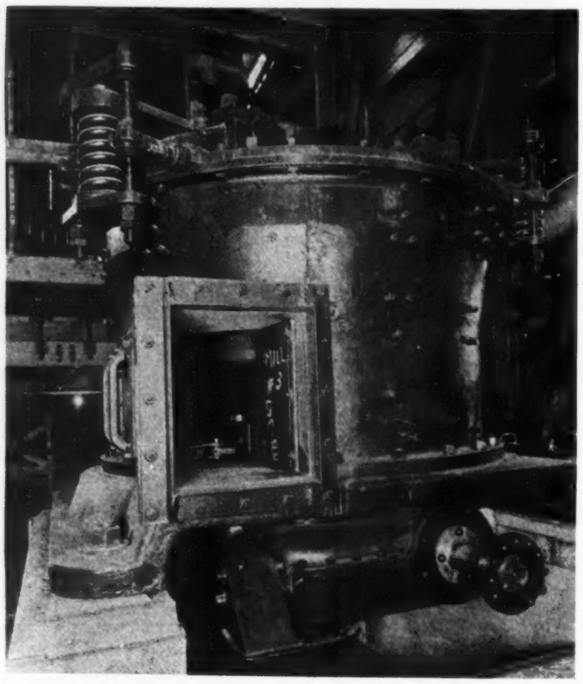


Views of boiler during construction

precipitator is carried away by a pneumatic conveying system.

Pulverizers

Two Raymond bowl-type unit mills, each of 20,800 lb per hr capacity, with commonly driven exhauster fans, and driven by Elliott squirrel-cage induction motors, are provided for each boiler. Control of fuel feed to the furnace is by joint regulation of the speed of the coal feeders through Sterling "Speedtrol" units, and the flow of primary air through the mills by dampers located at the inlets of the exhauster fans. One mill, exhauster fan and feeder for each boiler will normally be used for low loads and two will be required above half load. Combustion control has been so arranged that in changing from one-mill operation to two-mill operation, a manual adjustment of rheostats on the control panel will automatically reduce the operating mill to 80 per cent of its previous rating and cut in the second mill at about 20 per cent of the required total. Further adjustment gradually brings the two mills to an even division of load. The control panel is so arranged that the manual motions required of the operator are very simple.

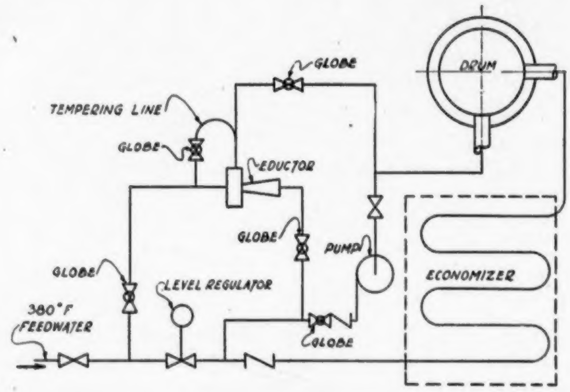


Bowl mill in course of erection

Feedwater Treatment

Chemical treatment will be introduced at the deaerating heater and the boiler drums. The condensate-return system is arranged for condensate from the low-pressure turbines to go to the high-pressure boilers, all makeup being introduced in the low-pressure boilers. Thus, the low-pressure boilers will, in effect, act as makeup evaporators for the high-pressure system.

In order to provide for maintaining the required pH value in the economizer without excessive feed of treatment, means are provided for recirculating from 2 to 4 per cent of the feedwater through the economizer. Two methods are being tried for this purpose. One consists of a motor-driven pump, taking the water from the drum and delivering it to the economizer inlet. This pump is provided with a labyrinth packing and a continuous leak-off which can be used as a continuous blowdown. The other method uses the pressure drop of the feedwater across the level control valve as the actuating medium of a hydraulic eductor to introduce water from the drum into the feed line ahead of the economizer. In order to prevent flashing of the boiler water in the eductor suction, a small amount of feedwater at 380 F is mixed with the drum water just ahead of the eductor.



Economizer recirculation eductor and pump connections

Waterside Station supplies steam to the New York Steam Corporation's distribution system through a tie connection having a capacity of 1,500,000 lb per hr. As soon as possible, after the initial operation of the high-pressure unit, experiments will be initiated to determine the amount of raw makeup which can be safely fed to the high-pressure boilers with a view toward supplying the base load of the Steam Corporation's system from high-pressure turbine exhaust.

Combustion Control

There will be no interconnection of the high-pressure steam or feedwater piping between units. Steam pressure for each unit is controlled at a common point between the superheater outlet leads from the two boilers.

Combustion control equipment is furnished by the General Regulator Corporation. The master steam pressure regulator consists of a Bourdon control element connected to an oil-operated regulator and integral relay cylinder. The speed of movement of this regulator is adjustable, as desired, to comply with the rate of response of the boilers and auxiliary equipment. The regulator is compensated to give constant steam pressure within plus or minus 5 lb at 1200 lb pressure. The master regulator is chain-connected to two potentiometer type dc rheostats, one for each boiler, so that movement of the master regulator is reproduced electrically in the form of loading voltages and distributed to the various equipment regulators through rheostats located on the master panel. A motor-generator set is provided for each boiler to supply direct current to the rheostats.

Six oil-operated regulators are provided for each boiler; one air volume regulator for the induced-draft fans, two feeder-speed regulators, two primary-air regulators and a forced-draft fan regulator. Of these, the first five are controlled from the master regulator and the last is weight or spring loaded.

Movements of the regulators are relayed to operating levers by motor-driven actuators. Electrical position

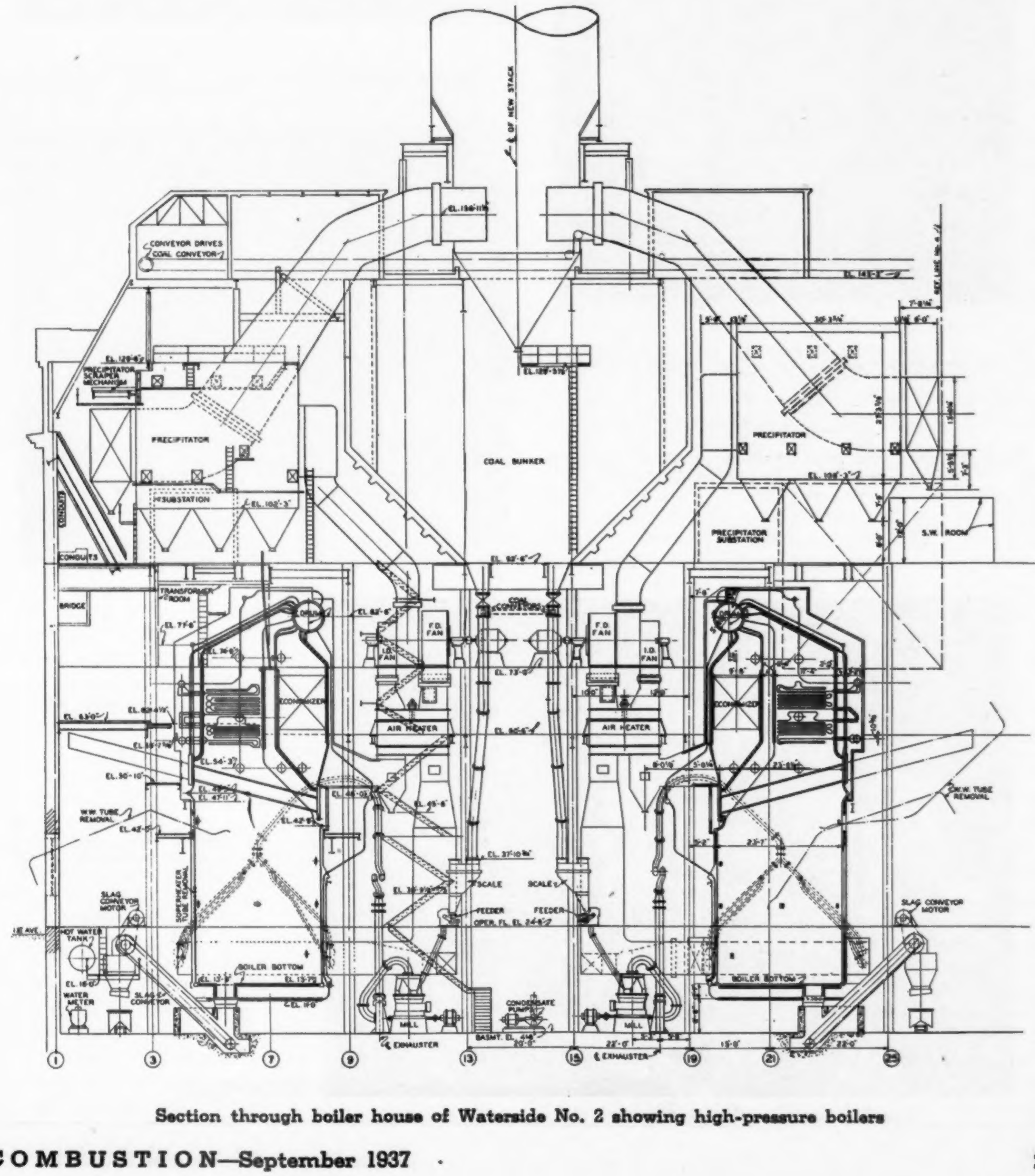
indicators are located on the master panel so that the boiler operator can observe the movements of each regulator and actuator. For hand control, provision is made for an actuator to be divorced from its respective regulator by means of a transfer switch mounted on the control panel. Push-button increase-decrease controls are also provided so that the operators can adjust manually any piece of equipment from the panel.

In normal operation, oil for master and equipment regulators is supplied by a motor-driven oil pump for each boiler but interconnection is provided so that either pump can supply either or both boilers.

A single Smoot feedwater regulating valve is installed for each boiler. These valves are operated by a 5-in. diameter oil piston controlled by a Smoot regulator. Water level is maintained in the boiler drums at a point about 6 in. below the drum center line and a change in drum water level effects an unbalance of a mercury U-tube or so-called "wobble-pot" which is fulcrumed in the regulator. The feedwater control valve is double ported and is designed to operate at high differential pressures across the valve, no excess pressure regulator being required.

Instruments

Steam flow, air flow and superheater outlet temperature are recorded on 12-in. round charts for each boiler by a Bailey boiler meter mounted on the boiler control panel. Feedwater flow is recorded by a 10-in. Builders Iron Foundry venturi meter on the deaerator inlet and a

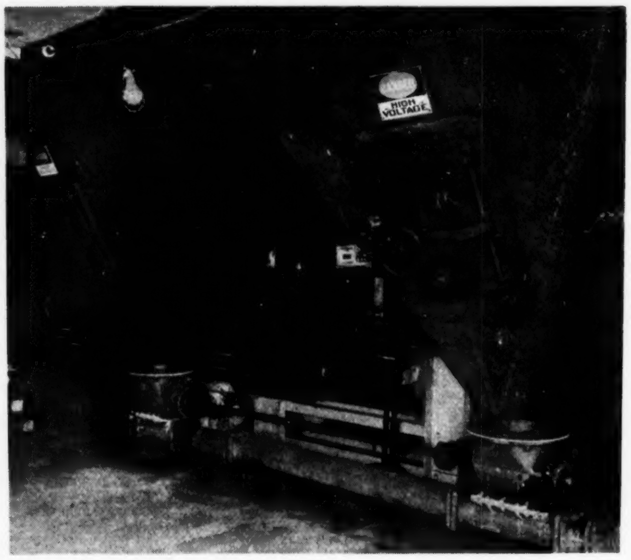


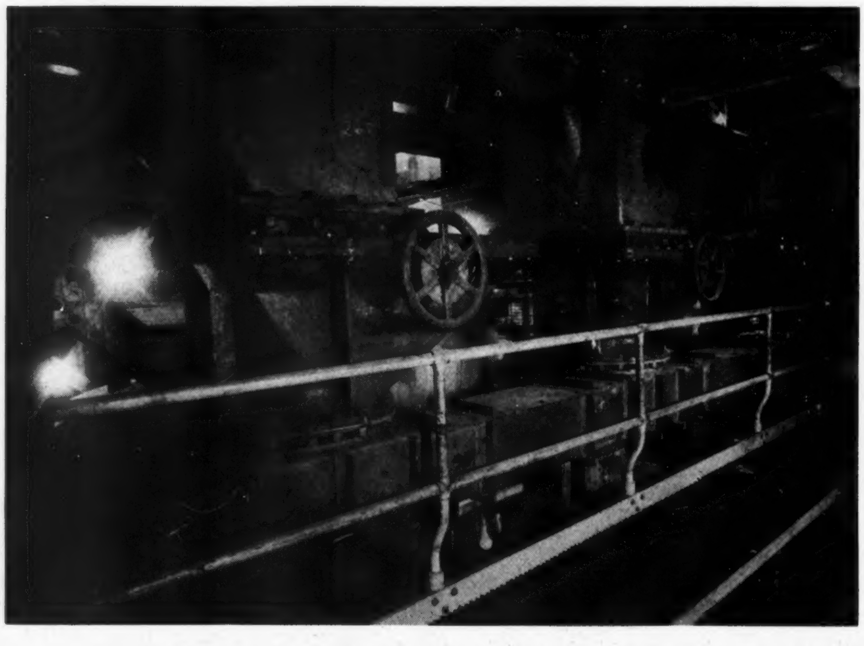
Section through boiler house of Waterside No. 2 showing high-pressure boilers

Above—Precipitator substation on the third floor

Upper view shows pulverized coal feeder in place

View at right shows hoppers under precipitators, with star feeders followed by pneumatic piping





Left—Raw coal gates and conveyor immediately below

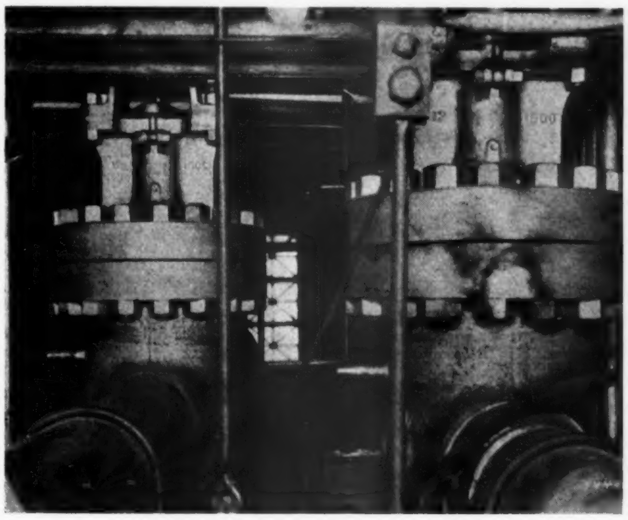
similar 12-in. meter on the deaerator outlet connection.

Three Leeds & Northrup potentiometer-type indicator-recorders are installed to read superheater outlet temperature from each boiler and temperature at the high-pressure turbine exhaust. Temperatures of flue gas and feedwater are shown by indicating pyrometers.

Piping and Valves

Considerable study was given to the selection of proper pipe materials for steam service at 1200 to 1400 lb and 900 F. For a period of one year before design started an investigation was made to determine what experience had been gained with steels of various kinds through research and actual use.

It has been and is at present the general opinion that carbon steel is unsatisfactory for piping service temperature higher than 850 F. The American Tentative Standard Code for Pressure Piping, the A.S.M.E. Boiler Code and other codes and practice definitely recommend a limit of 850 F for carbon steel pipe for steam power service. Valves and fittings of carbon steel, even at the approved adjusted pressure-temperature table rating for the 1500-lb series are not acceptable for this high-pressure, high-temperature steam service.



Main steam valves

The necessity of choosing an alloy steel was obvious and in searching through the field of application, reports of the high-temperature properties of the various alloy steels were studied. The oil industry presented more data on the subject than any other field as it has had more experience with the various materials during recent years. Oil cracking and gas processing, however, are confronted with the problem of corrosion and therefore, besides certain favorable high-temperature physical properties, proper alloy steels having suitable corrosion resisting qualities had to be selected for such services.

The steam power industry, however, has not advanced to the high-pressure, high-temperature stage at the same rate and although several high-pressure steam stations were in operation as early as 1929, temperatures were not then in excess of 850 F.

Experimental high-temperature steam applications had been started but the accompanying steam pressures were comparatively low. Although considerable knowledge was available from these experiments, the behavior of materials for piping when used under combined high temperature and high pressure was not generally agreed upon and it remained to select a suitable material with a sufficient factor of safety for the service.

Since the corrosive effect of steam at 1400 lb, 900 F is negligible it is not necessary to resort to high-alloy steels—an important point because of some of the undesirable physical properties of the high alloys such as temper embrittlement and special heat-treatment requirements. Carbon-molybdenum steel was chosen as most suitable since research on the material indicates that its physical properties are favorable for its use up to 1000 F.

Carbon-molybdenum steel behaves in many respects like carbon steel, but its qualities greatly exceed those of carbon steel at high temperature. It is a general feeling that carbon-molybdenum steel is as good physically at 900 F as carbon steel is at 750 F. This enables working under the assumption that valves and fittings of the 1500-lb carbon steel series standards will be suitable for 1400 lb, 900 F when the product is made in carbon-molybdenum steel of compositions given for this material in the corresponding standard specifications of the American Society for Testing Materials.

Pipe wall thickness was designed on the basis of the generally accepted modified Barlow formula, but a suitable value for allowable stress had to be selected. After investigation and comparison between the properties of carbon-molybdenum and carbon steel, a value of 10,500 psi was selected and a design pressure of 1400 lb was used although the service pressure is expected to be in the neighborhood of 1200 to 1300 lb. In solving for wall thickness, pipe of nominal wall thickness, on the plus side, was selected for corresponding nominal sizes from the proper schedule number of A.S.A. Standard B36.10-1935; i.e., if the wall thickness solved for came between two schedule thicknesses, the heavier schedule was chosen.

For the first unit, the main 1400-lb, 900-F steam pipe was furnished where required in sizes of 8 to 12 in. inclusive in accordance with Schedule 140, while sizes under 8 in. followed Schedule 160, all in carbon-molybdenum steel. The material for this pipe was ordered in accordance with grade P 1 of A.S.T.M. Specification A158-35T with the supplementary requirements of that specification.

The two 12-in. main steam lines are run separately from each of the two boilers and joined at the entrance to the turbine throttle valve at a hollow sphere of about $2^1/_4$ in. wall thickness and $4^1/_2$ ft in diameter. A single 20-in. outlet connects the sphere to the throttle valve. The sphere, forged in two halves from carbon-molybdenum steel and welded together, has welded forged carbon-molybdenum nozzles for the pipe connections. Piping joints on these main steam lines are all welded except the connections of the non-return stop check valves at the boilers where Sarlun joints are used.

For the second unit the 12-in. main steam lines, of carbon-molybdenum steel, will be of a greater wall thickness as all sizes will follow Schedule 160 of A.S.A. Standard B36, 10-1935. This has been done in compliance with an effort on the part of the Prime Movers Committee of the Edison Electric Institute, in conjunction with the steel mills, to standardize on a schedule for carbon-molybdenum pipe for steam services in order that the product may be rolled in quantity by the mills and placed

in stock for better deliveries. Since our service pressure and temperature falls between the two standard classifications, we have conformed to the upper class rather than pay an extra price and accept longer deliveries for special rolling.

Valves used on these lines are of the 1500-lb manufacturers' series but made in carbon-molybdenum steel for the bodies and bonnets and welded into the line. The stems of the valves are of stainless steel and the seating of steam non-return stop check valves is of Stellite while that of the main line stop valves has solid Nitralloy plug and seat rings.

The boiler feed discharge line from the pumps to the boilers starts with an 8-in. line from each of three pumps (one pump, steam-driven, is a spare), joins in a short section of 12-in. line which branches out into two 10-in. short lines, each through two high- and intermediate-pressure heaters in series, joining again in a short section of 12-in. line and then branching into two 8-in. lines, one to each economizer.

The maximum service pressure is calculated to be 1675 lb with a water temperature of 376 F. The pipe is Grade B carbon steel of A.S.T.M. Specification A106-36 and in accordance with Schedule 140 and Schedule 160 of A.S.A. B36.10-1935 for wall thickness for corresponding nominal sizes of 8 to 12 in. inclusive, and 6 in. and smaller, respectively. The supplementary requirements of this A.S.T.M. Specification were defined in sizes 6 in. and larger. Joints in this line are all welded except connections at the economizers and pumps which are Sarlun as on the main steam piping. Fittings are of carbon steel and special block forgings with welding ends are used for larger sizes.

Valves for this line are of the 1500-lb series with bodies and bonnets of carbon-molybdenum steel and stems of stainless steel. Seating on all valves for this service is stainless steel combined with differing compositions of seat and wedge or disk to prevent seizing and galling.

Piping for intermittent boiler blowdown service is carbon steel designed for 600 lb from the outlet end of blowoff valves to the connections at the tank. This is in accordance with the recommended practice of the American Tentative Standard Code for Pressure Piping, A.S.A. B31-1935.

On the 6-in. header of this blowdown system into which the boiler blowdown lines from the individual boilers, as well as drips and drains from valves and other lines discharge, are two asbestos-packed steel plug cocks operated in tandem and located one each in the branch "Y" connection which discharges the main into either the blowdown tank or overboard into a discharge tunnel. These cocks are so arranged that when either one is open the other is closed. This enables repairing the tank while diverting the blowdown flow to the tunnel without the possibility of shutting off the blowdown line.

Joints on this blowdown line are welded except at the cocks and valves at the tank which are flanged with standard raised-face flanges serrated with concentric grooves and using copper-plated soft-steel seamless ring gaskets. Discharge from the tank as well as connections in the discharge tunnel follow standard design for 125-lb service.

The three steam bleed lines from the turbine, one at 200, one at 60 and one at 5 lb, as well as the branch from the 200-lb line for auxiliary steam and the low-pressure auxiliary exhaust lines, are all of usual carbon steel design for respective pressure services except that all joints are welded throughout for pipe-to-pipe and pipe-to-fitting connections. Valves on the 200-lb lines are welded in the lines, but valves in the other bleed pressure lines mentioned are of cast iron and are therefore flanged in sizes 2 in. and larger, steel welding neck flanges being used for pipe-to-valve connections.

Salt water lines are of cast iron designed for 250 lb to allow for fire-service pump operation. Salt-water pump suction lines are designed for only 125-lb service. The pipe is cast iron in sizes of 4 in. and larger. Steel is used in sizes of 2 in., $2^1/_2$ in. and 3 in. while "red brass" is used for sizes under 2 in. Joints are all flanged in sizes of 2 in. and larger, screwed in sizes of $1^1/_2$ in. and smaller, and follow the American Standards for the service.

Cast-iron valves in sizes of 2 in. and larger for salt-water service are flanged gates and equipped with bronze-bushed stuffing boxes while valves smaller than 2 in. are a commercial bronze screwed globe product.

Fresh water lines for 125- or 250-lb service for the first installation are of steel pipe with welded-joint design. The valves are of cast iron, flanged in sizes of 2 in. and larger and welding neck steel flanges are used for such pipe-to-valve joints. Valves smaller than 2 in. are bronze screwed.

Precautions with Oil Lines

Oil piping is all steel and welded joint construction except cast-iron flanged valves in sizes 2 in. and larger. Our specifications prohibit cast-iron pipe on any oil line and cast iron, bronze or brass for valves or fittings on any lubricating oil lines, immediately connected to machinery. Bronze or brass and cast iron are also prohibited for any component parts of an oil line if it is located in close proximity to another pipe line conveying a hot material, the temperature of which would be high enough to cause ignition of oil dripping or spraying from a leak. The pipe is therefore steel throughout with welded joints except, where permitted, in sizes $^1/_2$ in. and smaller it is fully annealed "red brass." Oil piping is designed for 125-lb service.

All large valves on the main steam lines, boiler-feed discharge and 200-lb bleed and auxiliary steam services are motor operated for facility of normal operation as well as emergency closing. A local three-button push-button station for opening, closing and stopping each valve is located in close proximity to the valve it controls. Each motor-operated valve is also capable of emergency closing only from a remote point located on the boiler panelboard. Certain strategic steam service valves have a duplicate remote control closing station on a board in the Chief Engineer's Office for emergency. Two motor-operated 8-in. valves, located in the discharge lines from the booster pumps to the boiler feed pump suction lines, have their remote control stations arranged for opening and closing in normal operation from the control board in the boiler room.

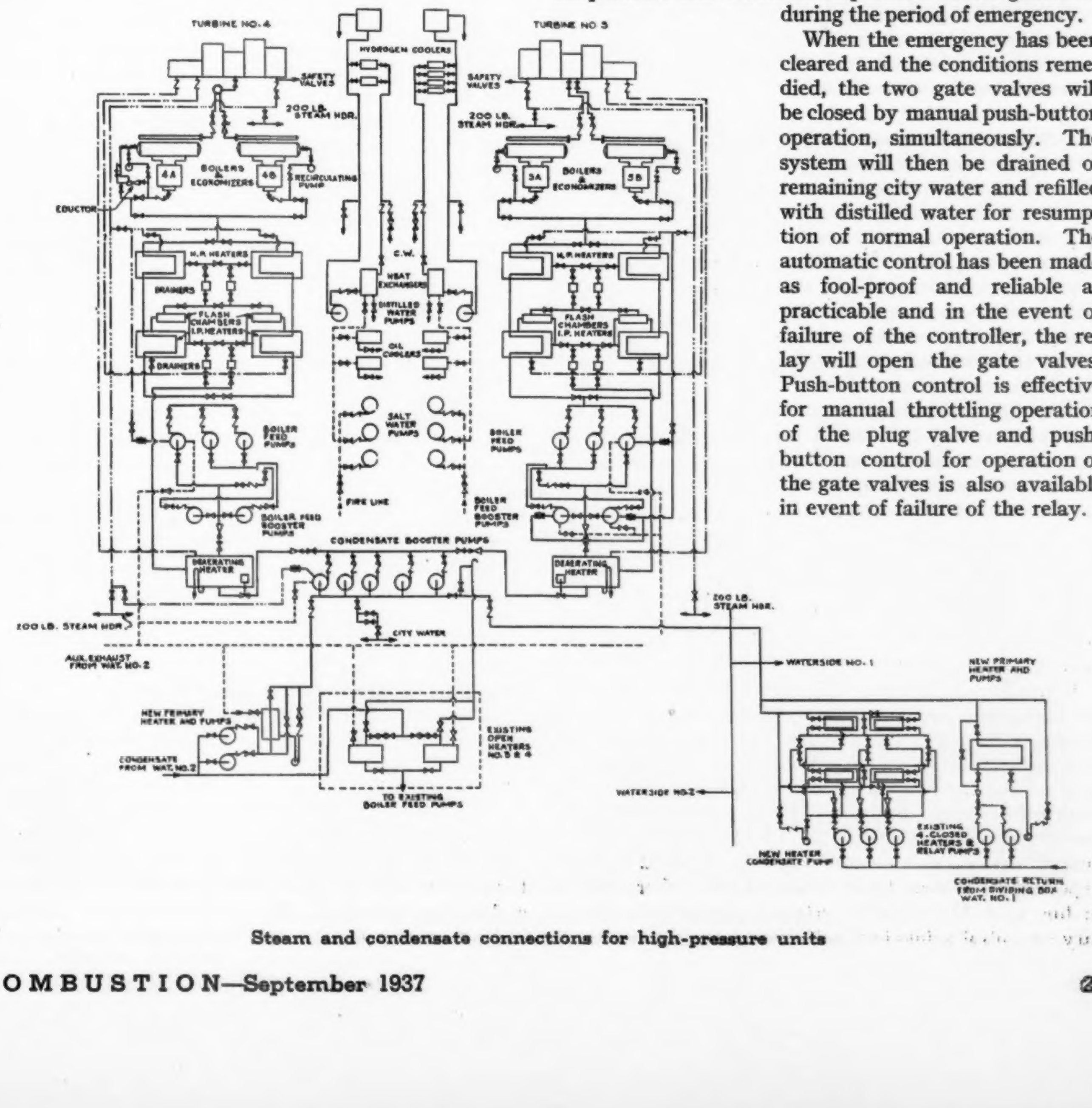
All motor-operated valves are capable of operation by handwheel through gearing to facilitate operation against unbalanced pressure in the event of electrical failure. Limit switches of all motor-operated valves are arranged for geared cutoff control at open and closed positions with a torque switch for final closing cutoff.

An electric-arc, fusion-welded butt joint is used throughout for pipe sizes 2 in. and larger and a socket-fillet weld is made in the small sizes. The usual form of V-groove is used for butt welds where the pipe wall is one-half inch or less and a 26 deg U-groove with a radius of $^5/_{16}$ in. at the bottom is used for greater pipe wall thickness. Welding is done by operators qualified under tests prescribed by the Travelers Indemnity Company for Classes A and B welding defined by the American Standard Code for Pressure Piping A.S.A. B31-1935. The joints are graded according to these two classifications and operators are permitted to work only on joints of those lines for which they have qualified.

Welds on carbon-molybdenum steel are made after preheating the parts to 600 F and the welding of the joint is continued without interruption until completed, after which stress-relieving is begun immediately. Covered electrodes are used with a direct-current arc and for welding carbon molybdenum steel, molybdenum is contained in the coating of the carbon-steel welding rod. All welded joints $2^1/_2$ in. and larger, falling under Class A, are stress-relieved by the employment of electric induction-type heating equipment and are X-ray inspected.

An interesting piping feature in connection with emergency cooling of the hydrogen gas of the generator-cooling system was worked out to permit the generator to operate at full load during a period of emergency failure on the part of the normal distilled water circulating system. This provides for the economical use of city water and is accomplished by means of a Leeds & Northrup "Micromax" control affecting two 8-in. motor-operated gate valves and one 8-in. motor-operated plug valve. The gate valves, one in the city water connection to the distilled water line to the hydrogen cooler and the other in an overboard line to the discharge tunnel, will normally be closed. During normal operation, distilled water will be circulating in a closed cycle through the hydrogen cooler, pump and heat exchanger, where the cooling medium will be salt water. If the distilled water pump fails or in some manner normal flow is prevented, the hydrogen gas temperature will rise and at a predetermined high point the Micromax controller functions to cause the two gate valves to open full, simultaneously. At the same time the controller causes the plug valve in series with and immediately after the inboard gate valve to operate. This plug valve opens or closes to such a position as required to permit the correct quantity of city water to flow through the hydrogen cooler for maintaining proper operating temperature of the hydrogen gas. As the load on the generator varies, the Micromax controller opens or closes the plug valve to throttle and proportion the flow of city water, thus maintaining proper temperature and economical operation of the generator during the period of emergency.

When the emergency has been cleared and the conditions remedied, the two gate valves will be closed by manual push-button operation, simultaneously. The system will then be drained of remaining city water and refilled with distilled water for resumption of normal operation. The automatic control has been made as fool-proof and reliable as practicable and in the event of failure of the controller, the relay will open the gate valves. Push-button control is effective for manual throttling operation of the plug valve and push-button control for operation of the gate valves is also available in event of failure of the relay.



Steam and condensate connections for high-pressure units

WATERSIDE NO. 1 STATION

The Third Step in Central Station Development in New York

As a companion to the description in this issue of the high-pressure steam-generating equipment in the revamped Waterside No. 2, Mr. Orrok, who was identified with the design of both Waterside No. 1 and No. 2 and with the Edison Company for many years thereafter, was asked to prepare an article covering some of the historical background of these stations and the problems involved in the design of Waterside No. 1 which started operation in 1900. The two articles provide a striking picture of the advances in central station practice during the past 37 years.—Editor.

By GEO. A. ORROK
Consulting Engineer, New York

ON September 4, 1882, Mr. Edison put into service the Pearl Street Station of the Edison Electric Illuminating Company of New York. This was the first central station for the generation and distribution of electrical energy to a number of customers of varied types, and the service has had a continuous existence up to the present time. The installation included four 250-hp B. & W. boilers with iron shells and cast-iron heads and headers, six 200-hp horizontal engines and six Edison 1500-light Jumbo dynamos, direct-connected to the engine shafts.

The Pearl Street Station, however, while it served well the demands of the early years of the electric lighting industry in New York City, met with an accident on January 2, 1890, when it was so badly damaged by fire that the service was discontinued for about six days. At the end of that time the damaged apparatus had been replaced by anything that could be obtained, the feeders had been reconnected, and since that date—January 9, 1890—there has been no cessation of direct-current service on Manhattan Island which affected more than a very few customers.

When Mr. Edison first laid out a system of lighting for New York he planned, for the territory south of 64th Street, thirty-eight distribution districts, each with a generating center. His invention of the three-wire system, and the economical advantages of concentrating the generation of current in large stations, caused a departure from this plan, but, as the demand for electric energy developed to proportions far beyond original expectations, it soon became evident that other stations in line with Mr. Edison's original plan would be necessary as central points in the distribution of electricity.

At the time of the Pearl Street fire it was seen that one station of this type would not be sufficient to supply the demand for electricity to a single district, since the three-wire, 125-volt system was limited to a little over a mile. Therefore, John Van Vleck, mechanical engineer and electrician of the Company, laid out the island into three districts and projected three direct-current stations which were built soon afterward and took over the load. The downtown station was located on Duane Street, the second district station at 26th Street, while the third district station was placed at 53rd. These stations were unique in design, having engines in the basement with boilers and coal pocket overhead. Babcock & Wilcox steel boilers of 400 hp were used and the Duane Street station was laid out for sixteen 600-hp Henderson vertical engines made by the General Electric Company. Later, these units were superceded by the Van Vleck disconnective engines of 625 hp, 1250 hp and 2500 hp. These engines were built by the Dickson Engine Company and the Southwark Foundry & Machine Company. Other stations were projected as annexes such as 12th Street and 39th Street and the flexibility of the system was increased by the three-bus system and the distance-controlled, disconnective junction boxes on the feeder system.

It is interesting to look back and see the increase in the use of electricity from September 4, 1882, when the service was started with something over 200 customers, up to the time of the Pearl Street fire when, roughly, 1500 customers were connected to the lines.

After the fire the load on the system increased still more rapidly from 1698 customers in 1890 to nearly 9000 customers in 1897, when these three stations and four other similar plants were in operation. The annual output at that time had increased to approximately 25 million kilowatt-hours and served 20,000 hp of motors and over 400,000 incandescent lights together with other apparatus on Manhattan Island.

Mr. Van Vleck was in close touch with European practice and had become acquainted with Ferranti, whose famous 11,000-volt station in London was just going into service. He had also seen the earliest rotary converters, and proposed to the Edison management that a new high-tension, alternating-current station should be built to supply all of the needs of Manhattan Island through sub-stations provided with rotary converters and storage batteries. Mr. Bowker, General Manager, in his annual report for 1898 had covered the design of

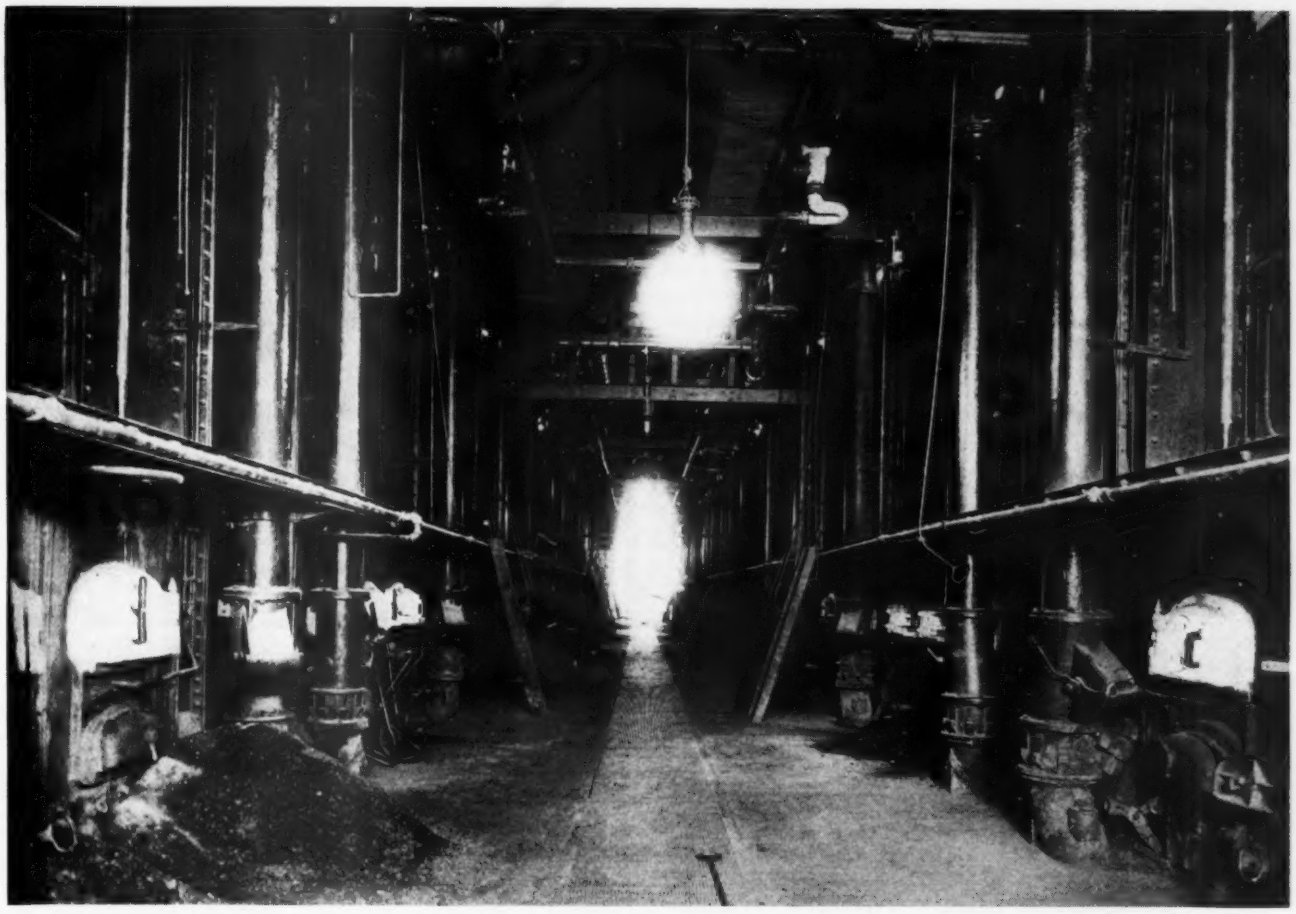


Fig. 1—Upper view shows firing aisle of old hand-fired boilers
Fig. 2—Lower view shows reciprocating engines and early turbines of Waterside No. 1

such a station with the reasons leading up to his proposition which the Board of Directors of the company had accepted. The following excerpts from his 1898 report with the drawings show the state of the development at the end of the year 1898.

The development into practical commercial apparatus within the few years past of rotary converters and other high-tension transmission appliances have made possible the use of annex stations, not containing steam generating machinery, but equipped with rotary converters and storage batteries. Two buildings of this character have been erected during 1898, one of 25 ft front at 200 Elm St., near Spring St., midway between tus which could be used in either direction, with the additional advantage that in case of emergency at Duane St. station, current could be supplied from uptown. There was accordingly installed in the Duane St. operating room two 400-kw and two 200-kw rotary converters, manufactured by the General Electric Company, and at 39th St. four 200-kw similar apparatus, all with the requisite auxiliary static transformers, etc. By this plan, direct-current is taken from the Edison bus bar at the usual voltage, converted from direct current to three-phase current at 80 volts by the rotary converters, raised to high tension by the static transformers, transmitted through the cables to static transformers at the receiving end, which in turn lower the current to 80 volts for use by rotary converters, started by direct-current and turning the 80-volt, three-phase current again

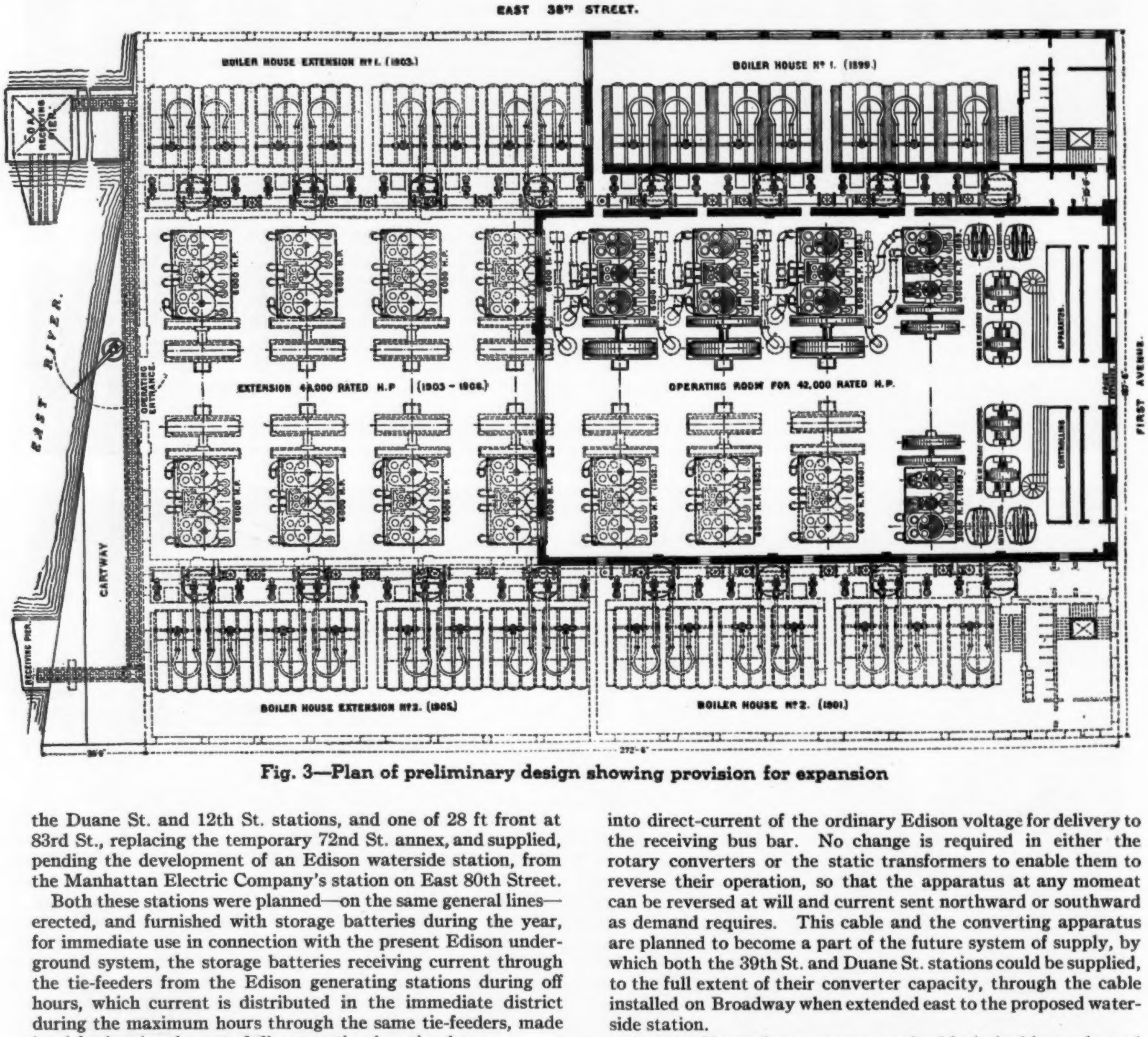


Fig. 3—Plan of preliminary design showing provision for expansion

the Duane St. and 12th St. stations, and one of 28 ft front at 83rd St., replacing the temporary 72nd St. annex, and supplied, pending the development of an Edison waterside station, from the Manhattan Electric Company's station on East 80th Street.

Both these stations were planned—on the same general lines—erected, and furnished with storage batteries during the year, for immediate use in connection with the present Edison underground system, the storage batteries receiving current through the tie-feeders from the Edison generating stations during off hours, which current is distributed in the immediate district during the maximum hours through the same tie-feeders, made local feeders by the use of disconnective junction boxes.

The probable demands of the year required that provision should be made for reinforcing the uptown district from the downtown district, and vice versa, pending the development of a waterside station system of supply. The maximum demands in the downtown and in the uptown districts come within the same hour, but at sufficient interval to make desirable an additional supply from downtown, at the extreme maximum uptown, and considerable economy can be effected by transmitting current from the great Duane Street station to the upper district during other hours.

Accordingly, it was planned to connect the Duane St. and 39th St. stations by a high-tension cable, through ducts existing along Broadway, and to install at both ends converting apparatus into direct-current of the ordinary Edison voltage for delivery to the receiving bus bar. No change is required in either the rotary converters or the static transformers to enable them to reverse their operation, so that the apparatus at any moment can be reversed at will and current sent northward or southward as demand requires. This cable and the converting apparatus are planned to become a part of the future system of supply, by which both the 39th St. and Duane St. stations could be supplied, to the full extent of their converter capacity, through the cable installed on Broadway when extended east to the proposed waterside station.

A waterside station, to occupy a city block, had been planned in outline in November, 1897, and control of suitable property secured in February, 1898. Before entering upon this important and final phase of development, it seemed desirable to make the most thorough inquiry throughout Europe, as well as in this country, as to the most improved construction and methods anywhere existing, with a view to providing the best possible construction and thus obtaining the most economical operation possible, before working out the final plans in detail.

Mr. Lieb, general manager, Arthur Williams, general inspector, and Mr. Van Vleck, consulting engineer of the company, were sent to Europe in June 1898 to get the

latest and final results of the best European practice, and they came back early in September with their notebooks full of data from practically every electric supply system in Europe and the preliminary designs of the station were immediately put under way. The writer at that time was in charge of the drafting room, and most of this preliminary work fell on him. The drawings (Figs. 3 & 4) taken from Mr. Bowker's 1898 report show the details of the preliminary design.

In the fall of 1898 there was a very widespread change in the ownership of the company, resulting in a change of management, and Thomas E. Murray became vice-president and general manager in full charge of the company's destinies under Anthony N. Brady, the trustee for the stockholders. Mr. Murray continued the engineering force in the design of the station, and enlisted the services of Elnathan Sweet, formerly State Engineer, as consulting engineer on the structural steel design. The architectural work on the facades was done by C. Wellesley Smith, while the rest of the design was done under Van Vleck's direction by the engineering department of the company.

During this period we made layouts covering a number of boiler designs and arrangements, several types of engines, and even the steam turbine was considered, although the largest available at that time was 250 kw. It was not known how well the rotary converters would work in connection with the distribution system, and even before the change in management, the company had purchased two sets of this new apparatus, installing them

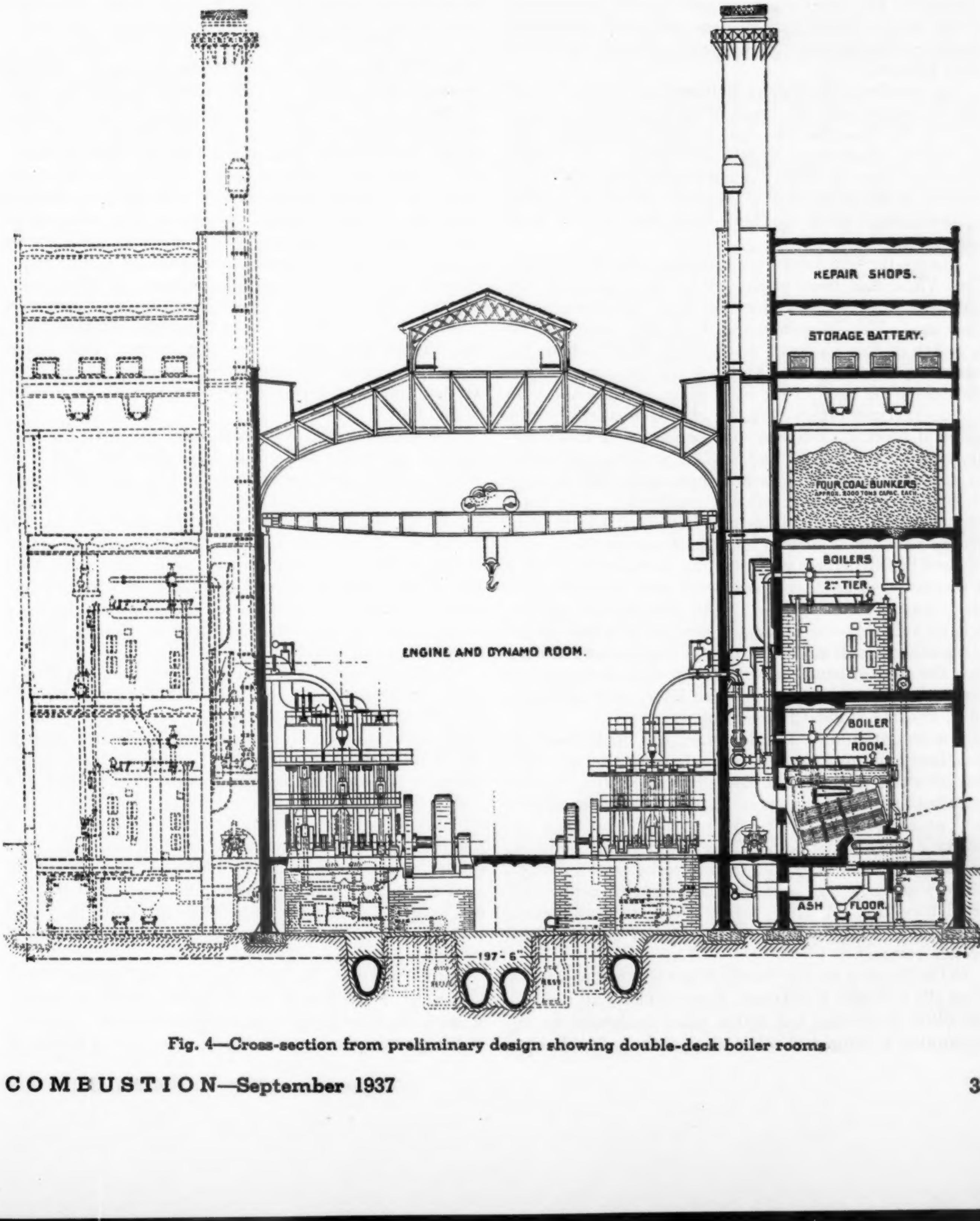


Fig. 4—Cross-section from preliminary design showing double-deck boiler rooms

at the Duane St. station, and the 39th St. station, and connecting them by two 6600-volt, three-phase lead-covered cables. This enabled these two installations to exchange electricity between the first and the second districts and thus take care of the diversity in the load. The peak in the first district occurred at 4:50 in the afternoon, while the peak in the second district invariably came on about 5:45 in the evening. About 400 kw of energy was transferred from the second district to the first district in the afternoon, and vice versa in the evening. This tie also permitted Duane St. to be shut down week-ends and 39th St. and 12th St. stations for some time in the summer.

The Chicago Company at the same time was experimenting with a similar high-tension installation, which proved so successful that work was immediately commenced on two sub-stations to take care of the increase of the load. These designs were completed before the change of management took place. (See excerpts from 1898 Report.)

The number of customers increased at a very startling rate during the next few years, 20 to 35 per cent per year, and, by the time the new station and sub-stations were in service, there were 28,000 customers. The output increased from 25 million kilowatt-hours in 1897 to 75 millions kilowatt-hours in 1900 and to about 100 million kilowatt-hours when the first Waterside engines went into service.

During the investigations preceding the design, Mr. Van Vleck had been impressed by the success of the air-break high-tension switches used by Semenza at Paderno. The Westinghouse Company was making a switch of this kind but neither type lent itself to the space requirements of a city block nor the climatic conditions on the bank of the East River. There had been some experimentation with oil circuit-breakers by the General Electric Company and Bergmann in this country and by the A.E.G. and U.E.G. in Germany, which promised economy of space and reasonably high capacity besides protection from weather conditions. The Bergmann designs (General Incandescent Arc Light Company) were finally chosen and the design of the switching and bus structures was taken up on these lines, using a succession of brick compartments with soapstone barriers for phase separation. The low-tension switchboards followed the standard Van Vleck edgewise designs so successful at the Duane and 26th Street Stations. For the control panels a benchboard with distance-control switches was developed which later, with push-buttons, became standard construction.

For excitation a radical departure was made from the standard Edison separately excited system. The original intention had been to install two smaller engines with both d-c and a-c generators, to be used for excitation and as an addition to the high-tension generating capacity. In the final design these engines were omitted, motor-generators were used for excitation and a storage battery of large size was installed for emergency and regulatory use. A large rotary converter sub-station of standard design was also installed and tied in to the exciter system.

In the design of the engines Mr. Van Vleck had patterned after the Ferranti 11,000-volt design which had been so successful in London but as the plans proceeded we incorporated a number of other ideas such as double low-pressure cylinders, poppet valves for the high-pressure cylinders, provisions for superheat, improved bearings, jackets and a reheater, feedwater heater and Wannick throttle valve. The success of Edwin Reynolds with the 96th St. engines of the Metropolitan Street Railway Co. led us to raise the outboard bearing, cutting down the stress in cranks and engine shaft about one half. These engines, rated at 4500 hp readily gave 7000 hp and at overloads carried about 9000 hp without undue strain. In fact, the m e p, referred to the low-pressure piston area, did not exceed 33 lb per sq in. Corliss valves on the low-pressure cylinders and the 1:6 ratio all combined to make such results safe and easy of attainment. The figured economy was around 10.5 lb per i hp which was bettered on the tests. The generators, made at Pittsfield by the Stanley Electric Company, were equally good, taking these overloads without strain or failure.

Operating Pressure of 200 Lb Selected

In 1898 the only central stations running at a higher pressure than 180 lb were the Duane St. and the 12th St. Stations of the Edison Company. At these stations the safety valves were set for 215 lb per sq in. and 210 lb was carried at the peak of the load and 190 lb ordinarily. Steel steam piping above 6 in. in size was very costly and nearly unobtainable. The Edison standard was Van Vleck's "Cannon" system of gun iron and he had settled on a nominal 200-lb pressure for the new station although the drums were good for 250 lb. Mr. Murray chose the standard three-drum 21 tubes wide, 14 tubes high B & W type boiler built by the Aultman & Taylor Company with cast-steel headers and the standard Edison ball and socket cross-overs. The boilers were the largest that any boiler company would build at that time and fifty-four were purchased, each rated at 650 hp.

The company had been experimenting with the finer sizes of anthracite and grates 12 ft deep by 12 ft 6 in. wide could be used under these boilers, hand-fired with the cheaper sizes of coal. Stokers had not been developed but negotiations with the manufacturer of the Roney stoker and with the McClave Company of Scranton were under way but did not materialize until after the station was in operation. Most of this development and test work was carried on under the direction of Mr. Murray and Mr. Van Vleck by George Fulton, Chief Engineer, and myself.

There are many other interesting details of the design, ring mains, duplicate feed system, combined air and circulating pumps, disconnective devices everywhere, large undercover coal storage and feedwater storage which later proved unnecessary. One of the most interesting features was the means used in providing and installing the condensing water intake. The top of this 12-ft tunnel was located about 4 ft below low water on a piled base filled with riprap where 60 ft of water originally existed. The tunnel, made of two circular concentric steel shells, held apart by struts and filled with concrete, was built at the Crescent shipyard at Elizabeth, N. J. and towed to place, sunk in its proper location and protected by riprap.

Actual work on the construction was started about December 1, 1899 with E. M. Van Norden (now mechanical engineer of the company) as Resident Engineer. A temporary plant consisting of one 200-kw DeLaval

turbine and one 500-kw Russell engine, running noncondensing, sent direct current out of the station in the winter of 1900, while the first large engine commenced service on the 6600-volt a-c system in the fall of 1901.

The contractors for the building were the P. J. Carlin Company, and for the steel construction, Milliken Bros. The engines were built by the Westinghouse Machine Company with Cyrus Robinson in charge of design.

Waterside No. 2

The Waterside Station had been so proportioned that it was expected that the new installation, with the help it could get from the older stations, would take care of the company's increased load until about 1910. The increase in 1899, however, was about 24 per cent, in 1900, about 33 per cent, and in 1901 about 35 per cent so that even before the engines of Waterside had started up the management had commenced to figure on the building of another station.

Mr. Van Vleck had carefully investigated the advantages of a station on the Hudson River, as well as a proposition for building a new station on the Jersey meadows to avoid troubles with the coal barges which in winter weather were a rather difficult problem. The difficulties in the way of this location with its submarine cables or overhead crossing were great and finally the Consolidated Gas Company offered the Edison Company the lot adjoining Waterside Station between 39th and 40th Streets and the Engineering Department in the summer of 1901 was instructed to go ahead with the design of a new station in this location.

Meanwhile, the development of the steam turbine had been carried on with great rapidity. The Westinghouse Company offered the Edison Company a 1250-kw horizontal machine which afterward went to the Dutch Point Station at Hartford, Conn. The General Electric Company offered 500-kw vertical units which were later installed at Newport, R. I. Both of these offers were rejected because of the small output, the engines at Waterside having generated over 4500 kw in an emergency. Finally, the General Electric Company settled the question forever with the 5000-kw units at Chicago and Waterside, which were soon followed by 7500-kw machines.

Waterside No. 2 Station, as finally laid out, consisted of ninety-six 650-hp standard three-drum B & W boilers on two floors, arranged in four sections with five overhead coal bunkers. Provisions were made for either eight or sixteen generators of from 5000 to 8000 kw capacity. Right in the middle of the design Mr. Van Vleck resigned to become Mechanical Engineer with the Subway Construction Co. Shortly afterwards the Chief Engineer, George Fulton, died and the design of the new station was carried out by the writer under the direct orders of Mr. Murray, the General Manager of the Company. Mr. Van Norden was loaned to the Brooklyn Heights Railway Company to have charge of the building of The Central Power Station of that company at Third Avenue and First Street, Brooklyn. C. B. Grady, later Mechanical Engineer of the Edison Company and now retired, was put in charge of Waterside No. 2 construction. The contractors on this work were the Murphy Construction Company and Post & McCord furnished the steel construction.

Effect of Sodium, Calcium and Magnesium Oxides on Ash Fusion Temperature

With a view to ascertaining the effect of alkali, in the form of Na_2O, CaO and MgO, on the fusion temperature of ash, recent investigations were made at Carnegie Institute of Technology[1] in which synthetic coal ash was employed. It was found that natural coal ash could be satisfactorily duplicated by using kaolin, having the composition of $Al_2O_3.2SiO_2$, as the source of the aluminum oxide and part of the oxide of silicon. The additional SiO_2 content was supplied by the pure oxide prepared from the dehydration of silicic acid. Pure Fe_2O_3, $CaSO_4$ (or $CaCO_3$) and Na_2CO_3 were used to complete the synthesis. The results showed that of the eighteen ashes studied, fourteen checked within 50 deg F with the natural ash and only two differed by more than 100 deg.

The next step was to investigate the effect on fusion temperature of varying percentages of sodium, calcium and magnesium oxides.

Since the oxides of sodium and potassium occur in relatively small amounts in most coal ash, their presence has been neglected in attempts to correlate fusion temperature and composition. However, the marked fluxing action of these oxides makes it desirable that some specific figures be available. In this study the ratios of the percentages of the other constituents of the ash, either natural or synthetic, were held constant, and the effect of definite increments of Na_2CO_3 on the fusion temperature was determined up to 4 per cent Na_2O, which represents about the upper limit in coal ash.

From 36 determinations, each run in duplicate, the average decrease in fusion temperature per one per cent addition of Na_2O was 50 deg F.

The relation between fusion temperature and CaO content was found to be practically linear, with an average decrease of 50 deg F for each per cent of calcium oxide up to five per cent. Above this the behavior was irregular, depending upon the percentage of the other constituents.

[1] These investigations were made by Thomas G. Estep, Harry Seltz and Willard J. Osborn under the auspices of Carnegie Institute of Technology and the Mining and Metallurgical Advisory Boards, the results being made available in Bulletin No. 74 just issued by the Institute at Pittsburgh.

Fuels Meeting

An attractive program of interest to power men has been announced for the joint meeting of the Fuels Division of the A.S.M.E. and the A.I.M.E. at the William Penn Hotel, Pittsburgh, on October 27 to 29. Among the topics to be discussed are the selection of coal for pulverizers and for stokers, burning anthracite and bituminous coals on chain and traveling grates, coal preparation, the burning of No. 4 buckweat, dedusting of coal, segregation in handling coal, the use of catalysis in combustion, the interpretation of laboratory tests and coal research.

STEAM CONTAMINATION—I

Causes, Correction and Measurement

By SHEPPARD T. POWELL
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This is the first of a series of three articles discussing this important subject. The present article takes up the influence of boiler design and operating conditions on priming and foaming, the influence of dissolved and suspended solids, and the phenomenon of selective carry-over of solids contained in concentrated boiler water salines. Results of numerous investigations are cited and an extensive bibliography is appended. The subsequent articles will discuss means of correction and measurement. This material, in expanded form, will appear later in the revision of the author's book, "Boiler Feedwater Purification"; hence all republication rights are reserved.

THE production of clean, dry steam has occupied the attention of engineers in the stationary and railroad boiler fields for many years, but has become a more urgent problem as the efficiency of steam-generating equipment has been increased by improved design. Trends in boiler design which have served the demand for economies in steam production have, in many cases, been prejudicial to steam quality and, as a result, there has been an intensified interest in the mechanism of steam contamination and its measurement and correction. Prior to 1900 there was little accurate published information on this subject, but development lately in steam generation has focused attention on this phase of boiler-water control. Like many other problems encountered in boiler operation, there is much controversial evidence on the subject. This has been due in part to lack of scientific facts and to the formulation of conclusions based upon insufficient and unreliable data.

When boiler water is entrained in steam, it leaves deposits of dissolved solids in steam mains and valves, superheaters and turbines, and if such deposits occur to an appreciable extent they are soon reflected in loss of efficiency or damage to the equipment.

Definition of Terms

The phenomenon which occurs when boiler water is carried over with the steam is frequently loosely defined, but as a result of the work of a number of investigators there is now a general agreement as to these definitions. *Priming* is the term usually reserved for the propulsion of liquid into the steam drum by extremely rapid, almost explosive, boiling of the water at the heating surfaces. It is a spasmodic type of behavior, as contrasted to the steady carry-over which may characterize normal operation. When priming occurs, the entire column of water in a tube may become filled with steam bubbles, so that density of the mixture is decreased and it expands rapidly into the drum, expelling water into the steam space and the steam outlet tubes. A more constant phenomenon which also accounts for steam contamination is *foaming*, which occurs when bubbles of steam rising from the heating surfaces produce a layer of foam on top of the water. The foam may fill the steam space to such an extent that some of it enters the steam tubes. In addition to priming and foaming there is also the propulsion of water into the steam space by the bursting of bubbles which, even in the absence of much foam, will result in a relatively small and fairly steady entrainment of moisture into the steam.

Influence of Boiler Construction on Priming and Foaming

The construction of the boiler has a marked effect on the priming and foaming tendencies of boiler water. Insufficient steam disengaging space is one of the most important factors. Size of the steam header, velocity of the steam leaving the boiler and other factors may accelerate both priming and foaming. The more obstructions within the boiler, such as staybolts, braces, baffles, etc., the greater will be the tendency for these operating difficulties to occur.

It is obvious that the larger the amount of steam which, on rising through the tubes, must break through a given area of water surface, the more turbulent will be the water in the steam disengaging drum, and the greater will be the opportunity for priming and foaming. Similarly, the larger the steam space above the water, the more difficult will it be for moisture to reach the steam tubes. Moreover, when steam storage space is small, a sudden demand for steam will result in a sharp pressure drop, followed by sudden evaporation at the heating surfaces that may cause priming. Production of dry steam will therefore be facilitated by boiler design which provides the maximum water surface and steam space, i. e., the largest drum diameter. It follows that the small drums often used in high-pressure boilers may impose a handicap on steam quality.

Steam disengaging area is greatest when the water level is at the middle of the drum, and since lowering the water level increases the steam storage space at the expense of steam disengaging area, it is of interest to consider which of these factors is more important. H. Vorkauf(1) contends that the decisive factor is the steam storage space, and that if the water level were dropped until it were in the tubes, reducing the disengaging surface to zero and giving maximum steam storage space, the best results from the standpoint of steam quality would be obtained. He cites experiments at the Technical University of Darmstadt, in which the allowable

load increased by more than 150 per cent when the water level in a 3-ft drum was dropped 12 in. This author also emphasizes the importance of drum size, pointing out that while the doubling of the diameter of the boiler drum doubles the steam disengaging surface, it multiplies the steam storage space by four.

Although there appears to be justification for attaching major importance to steam storage space, it is obvious that the total area available for passage of steam through the water is also important. While the writer agrees in general with the principles laid down by Vorkauf, diametrically opposite results may be obtained under some conditions. An extensive investigation to determine carry-over in one boiler plant under the direction of the writer showed that by lowering the water level in the drum, carry-over was increased, whereas when the water level was at the center of the drum or slightly higher, carry-over was reduced. The explanation is probably found in the position of the steaming tubes entering the drum. These tubes are so designed that when the water level is lowered circulating water is jetted into the drum violently because of the low head of water over the tube outlet. It is interesting to note in the case mentioned that concentrations of the boiler water salines are of relatively minor importance and the extent of moisture carried into the steam is not dependent upon concentration of solids in the particular boiler. However, the actual amount of solids entering the steam cycle will, of course, be greater under the given conditions if the concentration of boiler water salines increases.

The writer observed two very similar cases of severe steam contamination caused by faulty design of boilers with respect to the control of water level in the two top drums. The steam which was disengaged in the front drum was carried by tubes to the rear drum which was at the same elevation, and thence to the superheater header. However, the water level regulation was applied to the rear drum, where the density was greatest, and the water in the front drum rose until at times it flooded the steam overcomers. These tubes accumulated deposits of solids from the boiler water at the tube end which discharged into the rear drum, as indicated in Fig. 1. The high velocity resulting from this obstruction caused a jetting against the water in the rear drum, and the spray thus created was carried into the superheater header. Many similar cases have been observed and recorded by other investigators.

Although certain aspects of modern boiler design are prejudicial to good steam quality, boiler manufacturers are turning their attention to features of design which will overcome this difficulty and are including baffles, steam purifiers and other devices. These will be discussed in a following article.

As is well known, contamination of steam increases sharply with rate of evaporation. Vorkauf emphasized this by making the "permissible load" the criterion of performance in his experimental work. The relation of quantity of steam to be produced to physical facilities for releasing it may not only be upset by deficiencies of these facilities, which is a matter of design, but by evaporation at an excessively high rate. This may be due to deliberate over-loading, forcing the production of more steam than the design contemplated, or to unavoidable incidents of operation. Sudden opening of a steam valve, or cutting in a boiler quickly, may draw excessively upon the stored steam and the resultant pressure drop will cause violent evolution of bubbles. If a sudden rise in temperature is caused by removal of scale from a heating surface, the evolution of steam may be almost explosive in its violence. Obviously the more fluctuating the load, the more frequent will be pressure drops that may cause priming.

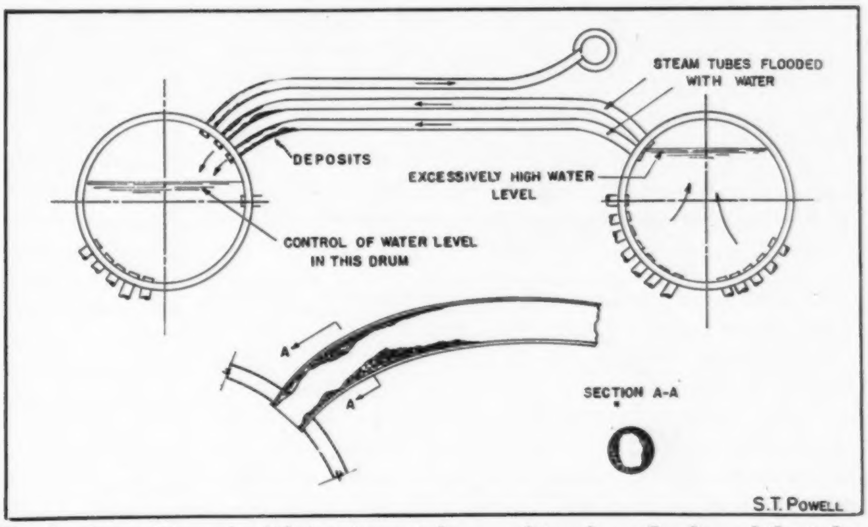

Fig. 1—Disposition of solids in steam tubes resulting from flooding of the tubes by high water in the front drum

In considering the phenomenon of priming, it is of interest that studies have been made of the velocity of rising gas bubbles in liquids. The relative velocity with which the bubbles pass upward through the water rising from an air lift pump has been determined by Hoefer(2) and Pickert(3) from measured weights of air and water. The latter author states: "Relative air velocities of 20 meters per second and more have thus been demonstrated." The velocity is expressed by Pickert as a function of the quantity of air released per second, divided by the cross-section of the tube, and is not directly proportional to this fraction but to a higher power of it:

$$V = \frac{C}{D_w - D_m}\left(\frac{W}{A}\right)^{1.23}$$

Where V = Relative velocity of air bubbles, meters per second.
C = Constant depending on temperature.
D_w and D_m = Densities of water and of the mixture of water and air, respectively.
W = Weight of air blown in, grams per second.
A = Area of tube, square meters.

Hypothetical values applied to this formula, using a 4-in. tube, give the curve shown in Fig. 2, where the relative velocity of the air bubbles is plotted against quantity of air released per second.

The relations derived for the performance of an air-lift pump are analogous to those that might be expected to hold for the rise of steam bubbles in nearly vertical boiler tubes, although changes in temperature, pressure, viscosity, surface tension and other factors would have to be taken into account. What is important is ve-

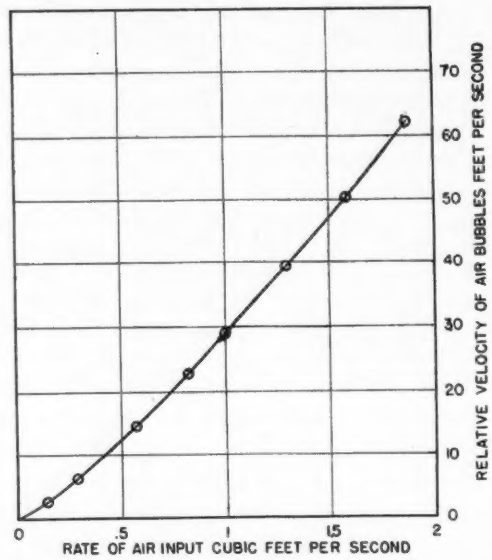

Fig. 2—Hypothetical values applied to the formula, using a 4-in tube

locity increase in proportion to a higher power of the rate of gas release and the reciprocal of the tube area.

Priming and foaming are not only favored by sudden changes of the water level, but also by rapid movement of the body of water due to changes in the position of the boiler itself, such as takes place in railroad locomotive boilers or in marine practice where the rolling of ships causes motion.

Other conditions being equal, high pressures are less favorable to foaming and priming than are low pressures, since at high pressures the formation of bubbles is retarded. Working with an experimental boiler, Joseph and Hancock(4) found that as the pressure was reduced from 155 lb to 70 lb, four to five times as much boiler salines was carried over with the steam. In an experimental boiler studied by J. A. Holmes(5) it was possible to look through the drum by means of opposite sight glasses, an incandescent light being installed behind one of these. It was found that the steam was opaque at high pressure, due to the bursting of bubbles which seemed to be confined almost entirely to the surface, while the water was transparent. As the pressure was lowered the water became opaque because of the bubbles formed, culminating in a thick foam on the surface, and the steam became transparent.

The influence of pressure on steam quality was demonstrated recently at a power station where 400-lb boilers and turbines had been added to the original 200-lb equipment. An attempt was made to operate the 400-lb boiler at 200 lb while part of the high-pressure station was down for inspection. The steam generating space of the boiler had been designed for satisfactory operation at 400 lb and at the lower pressure severe carry-over and fouling of the superheater was encountered. It is a recognized fact that the steam drums on high-pressure boilers are smaller than for lower pressure boilers due to the difference in density of the steam released under different operating pressures. Frequently this is ignored by operating engineers and serious troubles from carry-over have occurred which could have been avoided if basic facts of the boiler design were taken into consideration, especially the pressures for which the units were constructed.

Influence of Dissolved Solids

While it is familiar to boiler operators that priming and foaming are promoted by an excess of soluble salts and precipitated sludge in boiler water, the manner in which they exert their influence is not entirely established and has been the subject of much study. Attention has mainly been directed to seeking the mechanism by which dissolved and suspended solids assist the formation of foam. The most extensive published writings on this subject are those of Prof. C. W. Foulk(6, 7, 8, 9, 10, 11) of Ohio State University, and his associates. The work of Niehaus(12) and Vorkauf(1) has also added greatly to our knowledge of this problem and a review of these investigators' findings is recommended to those encountering such problems.

It is apparent that the ability of bubbles to form on the surface of boiler water is related in some manner to substances in the water. If a bubble of steam rises in perfectly pure water it will penetrate the surface and pass into the air without forming a film, even for an instant. When two bubbles collide under the surface of pure water they merge instantly to form a larger bubble and this also passes to the space above the water without remaining on the surface. On the other hand, solutions such as boiler salines have the ability to form films that constitute bubble walls, and even though these have only a momentary existence, they permit the formation of bubbles on the surface of the water, sometimes in such numbers as to produce foam. When steam bubbles are formed in boiler water, at the heating surfaces in the tubes, they are small because of the high pressure exerted on them. When they rise through the water they do not coalesce because a film separates them, and a film persists when they push up the surface of the water. There is thus built up on the water a layer of small bubbles characterizing a foam.

Investigators in the field of physical chemistry long ago established a theoretical basis for understanding foam formation, and have demonstrated experimentally many facts about the physics and chemistry of surfaces and thin films. Bancroft (13) in discussing the essential condition of foam formation, stated as follows:

"Freundlich (14) considers that no pure liquid can form and in this he is apparently right. He then deduces that a low vapor pressure, a low surface tension and a high surface viscosity are essential to foam.......

"To get a foam the only essential is that there shall be a distinct surface film; in other words, that the concentration in the surface layer shall differ perceptibly from that in the mass of the liquid. All true solutions will therefore foam if there is a marked change of surface tension with concentration, regardless of whether the surface tension increases or decreases. All colloidal solutions will foam if the colloid concentrates in the interface or if it is driven away from the interface. To get a fairly permanent foam the surface film must either be sufficiently viscous in itself or must be stabilized in some way......."

Professor Foulk has sought to apply these concepts to the foaming of boiler water. According to the theory, as he states it, the stability of a bubble wall, however brief, depends on the fact that the wall consists of three layers, one at the outer surface, one at the inner surface and one in the center. The concentration of dissolved salts in the surface layers is different from that in the

liquid between them, and as a result both the inside and outside surfaces of the film are acted upon by forces which distinguish them from the thin middle layer. There is a difference in surface tension, resulting from the difference in concentration, which restrains the liquid of the bubble wall between the two surfaces and gives the film a brief stability.

Foulk demonstrated a correlation between foaming, the failure of bubbles to coalesce under water and differences in surface tension such as have been described above. While these experiments were made at room temperature and lower pressure, the effect of dissolved solids on foaming in a boiler is not only a matter of practical experience, but has been studied by a number of other investigators. Holmes, working with the experimental boiler referred to, established the relative concentrations of various salts that could be tolerated without foaming. Giving sodium carbonate, which was the worst foam producer, a value of 100, he obtained by his measurements the following relative permissible concentrations:

Sodium bicarbonate	110
Di-sodium phosphate	140
Di-sodium phosphate + sodium aluminate	160
Sodium bicarbonate + sodium aluminate	195
Caustic soda + sodium aluminate	205
Sodium aluminate	275

On the other hand, A. R. Mumford, (15) in an investigation of a large number of boilers, was convinced that hydroxide was the single chemical influence in steam contamination. According to Hall, (16) a few parts per million of calcium will retard foaming. Niehaus thought that the sodium phosphate concentration must be limited to produce dry steam, while Vorkauf summarized his experiments by saying that "These results justify the assumption that the ability to cause foaming is about the same for all solutions investigated."

There has long been a general belief that sodium salts were related to carry-over and evidence justifies the conclusion that in excessive concentrations they promote foaming. There is little doubt that where such difficulties have been experienced, high concentrations of these salts have occurred. There are ample reliable data, however, to prove that it is possible to have excessively large amounts of sodium salts present in boiler water without these troubles occurring. Tablock and Thompson (17) showed that boiler water containing sodium salts in concentrations of 50,000 ppm did not prime.

C. Herschel Koyl, (18) in reporting on the foaming of water in locomotive boilers, stated that no foaming occurred at very high concentrations of sodium salts until suspended matter was present in the water. Koyl's statement is well known and is too lengthy to quote in its entirety, but is of interest because it was published more than thirty-five years ago and these findings have since been verified through carefully controlled experiments by a number of observers. Recently, experience and special studies have confirmed the theory that priming and foaming are due not only to concentration of sodium or other soluble compounds, but to the presence of suspended matter in addition to these substances in relatively high concentrations.

The boiler operator is limited in his control of the relative concentrations of the various sodium salts by the necessity of preventing scale and by inhibiting corrosion and embrittlement. It is doubtful whether an approach to the prevention of foaming by controlling the composition of the water can accomplish more than avoiding of excessive amounts of treating chemicals and limiting the total solids by blowing down.

Influence of Suspended Solids

It has long been generally believed that boiler sludge had some relation to carry-over, and a series of studies of the effect of suspended solids on foaming of boiler water was made by Professor Foulk and his associates. (8, 9, 10, 11) They found that various kinds of pulverized material caused foaming of saline solutions when boiled in glass receptacles in the laboratory, and minimum foaming concentrations of dissolved and suspended matter were established. It was observed that particles floated on the surface of the water and entered into the film, apparently giving it structural strength. However, the importance of this phenomenon in actual boiler operation was discovered to be doubtful when experiments were extended to a small laboratory boiler operating at 150 lb. The pulverized solids lost their ability to float and stabilize the foam after boiling for a few minutes. As soon as the powder was completely wetted, it had no effect on foaming.

The experiments were then modified by precipitating the suspended solids in the boiler in a manner identical with the formation of sludge. The results confirm the conclusion that boiler sludge, whatever its other influence on steam quality, does not stabilize foam to a great extent by floating on the surface and entering into the bubble wall. The foam-promoting behavior of the solids used in the first experiments was thought to be due to a coating of adsorbed oil or other impurities, which was removed by boiling at high temperatures. Holmes(5) observed that sludge lost its foaming-producing properties by "aging" in the boiler. If it is possible for oily pulverized matter to stabilize foam, the question arises whether oil in feedwater might not give the calcium and magnesium precipitates this ability. There appears to be the possibility that this would occur if the entrance of oil and the precipitation of sludge took place more rapidly than the cleansing of the sludge by boiling.

As in the case of dissolved salts, various suspended solids differ in their effect on the carry-over from the boiler. Foulk has demonstrated experimentally that calcium carbonate increased carry-over and that magnesium carbonate decreased it in a laboratory boiler. (10, 11) He also noticed a great difference which depended on the conditions under which the precipitates were formed.[1] If crystalline magnesium hydroxide appeared, carry-over was decreased, but if the normal gelatinous form was injected into the boiler it promoted foaming.

It is a familiar fact in water purification that the nature of floc particles may vary considerably depending on the composition of the solution in which they are formed. Thus we are accustomed to regard alum floc precipitated at one pH value as pure aluminum hydroxide, while at another pH value adsorbed sulphate ions will give an electrical charge to the particles. Professor Foulk has suggested[2] that a hypothesis might be developed relating the charge on the particles of boiler

[1] The author's experience checks this. Foulk's findings have long contended that the influences of suspended solids depend on their physical rather than their chemical state.

[2] A personal communication to the author.

sludge to their tendency to attach themselves to bubbles of foam.

All boiler water, even when the makeup is from evaporators, will contain some suspended solids. The nature and amounts of the solids vary greatly. Mud, sewage wastes, certain types of boiler compounds, loose scale, calcium and magnesium compounds and many other substances, when present as suspended matter, will cause foaming under some conditions. In the light of past experimental work, practical experience dictates that judgment must be reserved as to any possible negative effect of boiler sludge on foaming. It is probable that boiler operators will continue to believe it necessary to limit the suspended matter, as well as the dissolved solids, in the boiler water by blowing down.

When boiler feedwater is drawn from a supply which is polluted with industrial wastes, serious steam contamination may result. This is particularly the case where sewage or industrial waste containing vegetable oils constitute a portion of the polluting substances. The presence of such products results in the formation of soaps, greatly increasing the foaming characteristics. Similar effects may be encountered when the feedwater supply is contaminated with wool-scouring wastes, tannery effluents, meat packing wastes and other types of industrial by-products. Frequently these materials will volatilize at relatively low temperatures so that even where evaporators are used feedwaters still possess foaming characteristics as a result of greases or oils passing over with the vapor from the evaporator. The author has also observed that finely divided clays and other types of surface washings may, in the presence of concentrated alkaline salts, result in violent foaming.

Selective Carry-Over of Solids from Boilers

There has been much discussion among power plant engineers and designers as to the phenomenon of selective carry-over of solids contained in concentrated boiler water salines. In so far as the writer is aware, there is little definite evidence to confirm or to disprove such occurrences. It is a fact, however, that selective deposition of solids does occur, irrespective of whether such solids leave the boiler water surfaces as pure salts. According to the theory of selective carry-over suggested by some, this phenomenon is the result of concentration of solids in bubbles formed on the water surface within the boiler. It is contended that salts deposit out selectively in these surface films, in accordance with solubility equilibria of the various salts when present in such high concentrations as may occur when the film of solution is in contact with the steam above the boiler water surface. When the films explode, these salts are propelled into the steam surface and carried along with the steam. However, this explanation is so far purely theoretical.

On the other hand, selective deposition of certain salts on turbine blading and valve seats is an established fact. The author has analyzed solids collected from seats of turbine control valves which consisted of 95 per cent sodium sulphate, and only traces of caustic soda, sodium chloride, silica and other constituents which were present in the boiler salines in concentrations equal to or only slightly lower than the concentration of sodium sulphate. The apparent explanation is that the sodium sulphate, in passing through the superheater tubes, dried out more rapidly than the other salts and as a dry powder was thrown out more readily than the other contaminants in the steam, either by changes in direction of the gas stream or by centrifugal force. This will account also for deposition of silica on turbine blading.

Straub(19) attributes the adherence of solids to turbine blades to sodium hydroxide in the boiler water carried over with the steam. The effect of sodium hydroxide is explained by the fact that this substance can remain in solution at concentrations of more than 90 per cent and does not reach saturation and precipitate as a dried dust, as is the case with other soluble salts. Thus, when a droplet containing sodium hydroxide is carried into the superheater, it retains a moist, pasty consistency even at very high temperatures, and cements to the turbine blading other salts that would otherwise be carried through entirely dry. If, however, other salts are present in sufficient amounts, they will overcome the effect of the sodium hydroxide by their mere bulk as a dry powder which absorbs the moisture.

Professor Straub has carried out laboratory experiments, impinging steam of varying composition against a specimen blade, and has installed test nozzles and blades drawing steam from the main steam line of a central power station. These experiments led to the conclusion that a ratio of sodium sulphate to total alkalinity in the range between 3.5 and 4.6 markedly reduced turbine blade deposits. This occurred even though the total solids in the boiler water were increased from 260 to about 1200 ppm. Concerning the actual performance of the station turbine, he states: "The deposit did not appear to be causing any more difficulty at the end of the ten weeks than at the end of the first four weeks." The first four weeks were prior to the increase in total solids and sulphate-alkalinity ratios.

Professor Straub's theory is no doubt under practical test in many plants, where sulphate-alkalinity ratios are maintained considerably higher than the A. S. M. E. Code requires for the inhibition of caustic embrittlement, because of a desire to err on the side of adequate ratios at all times. Turbine performance data from a large number of such plants will make it possible to evaluate the efficacy of higher ratios in preventing deposits. Until final conclusions can be supported by such data, it is probable that low total solids, rather than high ratios, will be specified by most operators as the remedy for steam contamination.

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The Guffey Act, the Coal Market and the Industrial Consumer

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An analysis of price-fixing, under the Bituminous Coal Act of 1937, as it may affect industrial coal buying. There is also appended a digest of those provisions of the Act which directly relate to the marketing of coal.

THE operation of the price-fixing system provided in the Guffey Act is only comparable, in a superficial way, to that which obtained under the NRA Code. In a number of important respects, the present situation is quite different. These differences appear only upon careful examination, and some of them may not become apparent to the buyer of coal until after the law has been in effect for a time.

It is a matter of speculation as to how this experiment in price-fixing is going to affect the coal market, but the possible effects are of sufficient importance to the consumers of coal to justify even some speculative consideration at this time. Briefly summarized, the probable effects include:

1. Prices sharply higher than under most existing contracts, but not uniformly higher for all kinds of coal.
2. A new relationship of prices and values among individual coals, as compared with freely competitive price relationships of the recent past. Necessity for complete re-appraisal of relative values of all available coals, by every consumer.
3. Greater stability of price relationships among coals, but less reliability of supply of individual coals and sizes.
4. Variations in price of individual coals *above* but not below Code prices.
5. Greater emphasis on, and need for, discrimination among coals. Coal selection and purchase will be less a matter of trading and more a matter of engineering appraisal of values.
6. A period of readjustment of demand to the new price pattern, lasting for a year or two.

Both under the Code and under the Guffey Act, the minimum prices at which the coal from each mine, and each size from each mine, may be sold, were and again will be established by boards, representing the operators for each of twenty-three districts into which the coal producing areas are divided.

A price pattern having been established by each board for its district, independent of the action of boards representing the other districts, then the boards representing districts which are in competition with each other in common consuming market areas, are expected to confer together, and arrive at mutually acceptable price relationships.

Price Pattern under Guffey Act

In a general way, the initially adopted price pattern under the Guffey Act will probably resemble that adopted under the Code. It should be remembered, however, that throughout the period of the Code, the coordination of prices among districts, and in some cases of individual prices within districts, were subjects of dispute within the industry, which had not been settled when the Code was abandoned. Therefore, while the price pattern may be expected to follow, in general, that established under the Code, there are likely to be differences in relative prices which will be of direct importance to individual consumers, and consuming localities.

The price level for steam sizes may be expected to be established about 25 to 35¢ per ton above the NRA Code prices, which were in effect at the end of the Code experiment, and more than that amount above the prices in most of the coal contracts made within the past year.

Enforcement and Changed Market Conditions

Price fixing under the NRA Code came at a time when the demand for coal was still abnormally depressed, and amounted to an attempt to maintain arbitrarily a price level in the face of a naturally very weak market, especially for those sizes and kinds of coal chiefly used by industry. And the means provided for enforcement were inadequate to withstand any competitive pressure.

Since then, the demand for coal has increased by a very substantial amount, for a number of weeks during the past winter approximating that of 1929, and the full force of a progressive shift in demand among kinds and sizes of coal, which has been going on for a number of years almost unobserved, is now being felt as a distinct market influence.

Severe penalites and methods for detailed enforcement are provided in the Guffey Act, and practically all existing contracts for coal (only excepting those signed before June 16, 1933) are outlawed as to price. Therefore, unless the operation of this law is stayed by the Courts, practically all coal sold will soon be at the official prices, and practically all consumers will be simultaneously affected.

Effect of Price-Fixing on Supply and Demand

Price fixing under the Guffey Act will therefore be undertaken under very different economic and administrative conditions. Assuming that it is possible to com-

* Chairman, Joint Committee on Fuel Values of the A. I. M. E and the A. S. M. E.

pel adherence to official prices by the exercise of the powers of Government, it is not possible for any one to foresee or control the effect of the fixed prices upon the demand for and consequently the production of individual coals, so long as the consumer is free to choose among the competing, but not identical, products of hundreds of mines, or to shift back and forth between coal and other fuels.

The individual consumer can do nothing about the price level but he can and will adjust his selection of individual coals to take the best advantage of the price differentials and the varying qualities of coal available as they affect the performance of his plant. These differences in price and quality are inherent from the very nature of the product, and the industrial consumer's actual fuel cost is capable of substantial variation according to the way he adjusts his coal selection to the prevailing price pattern.

Very few mines today produce a single product. Their output consists of a variety of sizes, the proportions of which are determined by the nature of the coal and the mining methods. Under a free market, a mine could reduce the price of one of these fractions of its total output, in order to balance orders with production, and thus enable it to fill the orders for the more important portion of the whole. That will no longer be possible, and the effect will be to limit the output of all sizes to that which corresponds to orders for the size in least demand. This effect, combined with any shifting of relative demand, may easily result in temporary shortages of individual coals and in actual prices for individual coals which are *higher* than Government prices, at various times and by varying amounts.

Price Differentials among Coals No Longer a Regulatory Force

There have always been differences in price among the products of the thousands of mines. These differences, at any given time, have been governed by the relative supply of and demand for the many kinds and sizes of coal available in any competitive consuming area. They have varied from time to time as the demand and supply has varied. Even assuming that the price level remains constant, the naturally elastic nature of the differentials themselves has operated in the past to adjust production to demand, or demand to production. For example, under certain circumstances, a particular mine may have orders for larger sizes in such quantity, that the accompanying output of smaller sizes is above the current need for them. In order to induce consumers to take in, and store, for future use, this excess, the price for the smaller sizes is temporarily reduced, thus balancing the demand for the several sizes. Only by some such method can a mine produce the larger sizes when they are demanded. The need for such variations in price is not always predictable for a given mine.

In a similar way, under conditions of great industrial activity, there may be, and usually is, a disproportionate increase in the demand for coals having qualities favorable to use at high combustion rates. The tendency is for the price for such coals to rise faster, or drop slower, depending on whether the price level is rising or falling, than the price for coals which are not so well adapted to extreme conditions of use.

All consumers are not, however, affected in this way simultaneously or to the same degree. Therefore, as the differential in prices increases, consumers who have been using those coals which are gaining in demand, but who do not so imperatively need that type of coal, are induced to change to coals which now cost enough less to make their use profitable Thus consumption, too, is modified by elastic price differentials, and adjusts itself automatically and in unpredictable ways, to changes in the relative demand and supply.

There is no method in view, within the prescribed price-fixing plan under the Guffey Act, for any substitute for this natural regulator of supply to demand among the thousands of coals and the users of them. The price pattern, under any such ponderous method of arriving at prices as is to be established, is certain to be sufficiently rigid to lose the natural responsiveness to variations in relative supply and demand. The regulatory effect of spontaneous variations in price differentials will disappear, or at least be severely restricted.

Therefore, assuming that a rigid price pattern becomes a reality, the probability is that fluctuations which have heretofore taken place in relative prices, will be transformed into variations in the available supply of individual coals or sizes. Greater price stability will have been obtained at the cost of less certainty of a uniform flow of any given size and kind of coal. The business of coal buying for an industrial plant stands a considerable chance of taking on some entirely new characteristics, somewhat similar in nature to the difficulties encountered during periods of general shortage of supply, even though the potential output of all sizes and kinds of coal is in excess of total demand.

How Coal Market Conditions Have Changed Since 1933

When the Code was established, the demand for bituminous coal had been declining since 1926, the rate of decline being sharply accelerated after 1929 by the decline in industrial production. Over a large part of the bituminous fields, the United Mine Workers' organization was demoralized and practically impotent. It was a "buyers" market of the most pronounced kind, particularly for those sizes and kinds of coal chiefly used by industrial plants.

The Code price structure, which was intended to lift and maintain prices particularly for those sizes and kinds of coal for which demand was most depressed, was under severe pressure of economic forces, which were irresistible, under the weak restraints provided by the Code system. For a year the effect was but slightly felt, because a large part of the industrial tonnage was moving under contracts made prior to, and in anticipation of, the Code. When new contracts, in substantial number, came to be negotiated in the spring of 1935, the price structure began to rapidly collapse, and the complete failure of the plan from natural causes was only obscured by the invalidation of all Codes by the Supreme Court decision.

Since the spring of 1935, the demand for bituminous coal has risen at an increasing pace, until during the past winter it approximated that of 1929. Part of the demand during the winter, but apparently not over 5 per cent, was for increases in consumers' reserve stocks, accumulated in anticipation of a possible coal strike, an almost certain increase in price due to wage increases, and the probability of price-fixing. This increase in demand has been almost entirely confined to those sizes and kinds of coal used by industry.

New Underlying Market Conditions

During the decade since 1926, certain fundamental changes in the nature of demand for bituminous coal have been progressively taking place. The cumulative effects of these changes upon the bituminous market situation were, for the time, completely offset, and so obscured by the decline in total demand for coal for industrial purposes since 1929. During this decade, the household and small commercial demand for coal, chiefly for heating purposes, was subjected to progressive invasion by oil and gas, and the use of coke for these purposes increased. The small stoker has come into increasing favor. All of these factors steadily diminished the demand for the larger sizes of coal. The use of the small stoker also increased the demand for smaller sizes of coal. The larger industrial users, who were not already using the small sizes, were shifting their demand for coal in that direction.

Under the surface, therefore, while the total current demand for small sizes was declining temporarily at a faster rate than was the demand for the larger sizes, there was taking place an important shift in the relative potential demand from the larger to the smaller sizes. As the previously existing, but temporarily latent, demand for industrial types of coal has been restored, the normal source of supply is found either to have been diminished by a reduction of demand for the larger sizes (of which the smaller sizes are only by-products), or partly absorbed by a new type of demand which has unobtrusively grown up since industrial production was last at these levels.

The effect of all this, marketwise, is simply that the smaller sizes of all kinds of coal, instead of being in a constant state of over-supply, are rapidly approaching the position of being in greater relative demand than the larger sizes. There is not available any data on the use of coal to determine the exact point at which we now find ourselves in this transition, but obviously a continuation of the trends of the last decade will some time make it necessary to mine coal simply to supply the demand for the smaller sizes. The action of the market in recent months indicated that in some sections this condition is already being approached.

The effect of this shift in relative demand is not confined to differences in size alone. Emphasis naturally falls on that aspect of the matter, but the changes taking place as a result of the installation of small stokers, and the modernization of larger plants, also tends to increase the relative demand for types of coal for which the large industrial consumers have heretofore been the only consumers, and for those types of coal which, because of disqualifying physical or chemical properties, have had only a limited outlet, even among that class of consumers.

In other words, we appear to be rapidly approaching a market condition of relative supply and demand among sizes and types of coal, which is entirely new and has never before been experienced in this country. There is an intimate relation between this situation and the operation of a price-fixing system.

Digest of Some Provisions of the Bituminous Coal Act of 1937

Coal Contracts

The sale or delivery of coal on contracts entered into since June 16, 1933, at prices below those to be established, is declared to be a violation. Until prices have been established by the Commission, no contract may be entered into which provides for delivery for a period longer than thirty days from the date of the contract.

Enforcement and Taxes

The Commission is required to promulgate the provisions of the Law relating to the formation of the district boards, marketing, prices and rules governing unfair methods of competition, as the "Bituminous Coal Code." The provisions of the Code apply only to producers who accept membership in the Code, but all producers are taxed 1¢ per ton for all coal sold. Acceptance of the Code is "voluntary," but those producers (if any) who prefer not to accept the Code, will also be taxed $19^1/_2$ per cent of the sale price of all coal sold.

A Code member, who has been found, after a hearing, to have violated the Code, may have his membership revoked by the Commission, which automatically makes him subject to the $19^1/_2$ per cent tax, until he is reinstated. The Commission may, however, first issue a "cease and desist" order. A producer, whose membership has been revoked, has the right to have his membership restored upon payment of double the tax, which would have been imposed upon the sale price of the coal sold in violation of the Code.

For purposes of enforcement, all Code members are required to report all spot orders, and file copies of all contracts, invoices, credit memoranda and furnish such other information as the Commission may direct.

Any Code member, whose business is injured by the violation of the Code by another Code member, may sue and be entitled to recover threefold damages, and the cost of the suit, including a reasonable attorney's fee.

Coal sold to States, or any political subdivisions for use in performance of governmental functions is not subject to the 1¢ tax imposed under this Act.

Districts and Minimum Price Areas

The coal fields are divided into 23 districts, and these are grouped into 10 minimum price areas. Two minimum price areas, including 12 districts, account for 90 per cent of the production. The remaining price areas and districts include outlying fields in the southwest and west, which serve localized markets.

"Minimum Price Area No. 1" includes all the bituminous production in Pennsylvania, Maryland, Virginia, West Virginia, North Carolina, eastern Kentucky, Ohio, Michigan and a part of Tennessee.

"Minimum Price Area No. 2" includes western Kentucky Illinois, Indiana and Iowa, each of which constitutes a district, numbers 9, 10, 11 and 12, respectively.

How Prices Are to Be Fixed

Strictly speaking, all power to fix prices is lodged with the Commission, but in practice the prices to be established are initially "proposed" by the several District Boards, composed of representatives of the operators, and one labor representative. Each district board, proposes the prices for its district, "from time to time on its own motion, or when directed by the Commission."

The prices proposed for each district shall be so arranged as to yield an average return per ton for the district equal to the average cost per ton for the entire minimum price area, within which the district is situated. For example, the prices proposed for coals in eastern Pennsylvania must yield to that district an average return per net ton which is not less than the average cost of production in the whole of minimum price area No. 1, including the remainder of Pennsylvania, northern and southern West Virginia, eastern Kentucky, Ohio and Michigan. Each of the other districts must do likewise, regardless of the average costs within the individual districts. The weighted average cost of production for Minimum Price Area No. 1 of $2.22 has been announced by the Commission.

Whenever any district board presents to the Commission satisfactory proof of a change in the average cost for a minimum price area in excess of 2 cents a ton, the Commission shall increase or decrease the minimum prices accordingly.

Price Differentials

Prices will differ among mines within a district, and among the sizes produced by each mine. The prices for coals produced in one district are related, in a practical way, to prices established for coals produced in other districts, and sold in common competitive markets. These differentials in price have always existed irrespective of the *level* of prices, and in a free market have varied constantly, reflecting changes in selective demand for and the relative supply of different kinds and sizes of coal. The Commission and the district boards are now charged with the duty of establishing a rigid price pattern, which in its infinite detail, will somehow approximate the price pattern which would result from the interplay of the natural market forces.

The Law says, with respect to price differentials *within a district:*

"Each district board shall . . . propose minimum prices . . . for kinds, qualities and sizes of coal . . . and classification of coal and price variation as to mines, consuming market areas, values as to uses, and seasonal demand."

"The minimum prices so proposed shall reflect, as nearly as possible, the relative market value of the various kinds, qualities and sizes of coal, shall be just and equitable as between producers. . . and shall have due regard to the interests of the consuming public."

Price Coordination among Districts

After the several district boards have each arrived at a schedule of prices, which conforms to these requirements, at a price level which is expected to yield an average return equal to the average cost of all coal produced within the price area, then they are to coordinate prices among districts.

In addition, prices thus coordinated, "shall not, as to any district, reduce or increase the return per net ton. . . below or above the minimum return. . . by an amount greater than necessary to accomplish such coordination, to the end that the return per net ton upon the entire tonnage of the minimum price area shall approximate the weighted average of the total costs per net ton of the tonnage of such minimum price area."

These provisions are intended to prescribe the exact process by which the district boards shall arrive at the thousands of price differentials, which heretofore have been determined by the free interplay of market forces. It was the failure to solve this problem, which more than anything else, demonstrated the unworkability of exactly the same price-fixing scheme, when it was attempted under the NRA Code. Under the NRA Code, there was no compulsion to reach agreement, but under the present Law, if the district boards fail to agree, the Commission has the power to establish prices and to enforce their observance.

Maximum Prices

The Commission is empowered to establish maximum prices, when it deems it necessary to protect the consumer against "unreasonably high prices."

Jobbers and Retailers

"The Commission . . . shall require the maintenance and observance of prices, and marketing rules and regulations established under the Law by distributors, who purchase coal for resale and resell it in *not less* than cargo or railroad carload lots."

Production Control

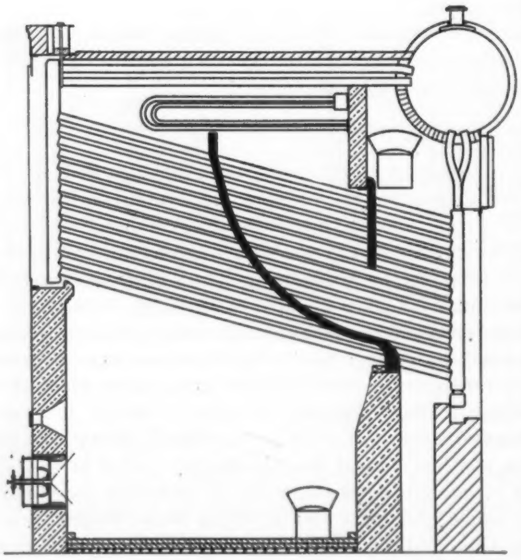
"The Commission shall, . . . investigate the necessity for the control of production of coal and methods of such control, including allotment of output to districts and producers within such districts . . . ."

Consumers' Counsel

The Law provides for the appointment by the President of a Consumers' Counsel who shall "annually make a full report of the activities of his office directly to Congress."

The counsel is also authorized to make complaint to the Interstate Commerce Commission with respect to coal freight rates, and to intervene in any hearings resulting from complaints filed by others.

Enco Baffle Walls



A Streamline Baffle design for a boiler and furnace changed for oil burning. An excellent furnace was secured. The curved Baffle gave improved heat transfer and helped to prevent soot and fly ash in the rear passes.

ENCO Streamline Baffles are now being applied to all types of boilers, the Horizontal as well as the Vertical.

Streamlining is most valuable; it eliminates eddy currents, it provides a more effective distribution of gases over the heating surfaces and it aids in preventing the accumulation of fly ash and soot among the tubes of the boiler.

Every ENCO Baffle is especially designed and built to meet the conditions surrounding each installation.

The Baffle work can be done without disturbing the brickwork and the details of construction are such that the replacement of boiler tubes is materially simplified.

Send us a drawing and the operating conditions. We will be glad to offer suggestions.

Write for Bulletin B-37

THE ENGINEER COMPANY
17 Battery Place New York

STEAM ENGINEERING ABROAD

As reported in the foreign technical press

British Electricity Output

The Electricity Commissioners report 1,588,000,000 kwhr of electricity generated by authorized central stations in England for the month of July 1937. This represents an increase of more than 13 per cent over that of July 1936. For the first seven months of this year the total putput was 12,810,000,000 kwhr or 13.4 per cent over that of the corresponding period last year.

High-Pressure Steam Accumulators

The Electrical Times (London) of August 5 comments on a paper recently read by Herr Stipermitz in Vienna which described the high-pressure steam accumulators at the Simmering Power Station. These accumulators, of which there are eight, are 4 ft diameter by 30 ft long, constructed of forged steel, and are filled with steam at 1700 lb pressure from a forced-circulation, high-pressure, oil-fired boiler. The station operates at 500 lb; hence the steam passes through a pressure-reducing valve on its way to the mains.

Stoker and Pulverizer Lubrication

Engineering and Boiler House Review (London) for August contains an article by H. N. Bassett on the lubrication of coal handling equipment in which the lubrication of stokers and pulverizers is discussed at length. The recommendations are of interest and differ in some respects from American practice.

The author advises the use of grease, applied by means of a gun for stoker bearings, a high grade of oil, oxidation resistant and free from sludge-forming tendencies, for the gears and oil for the driving mechanism. Grease for the bearings acts as a seal to prevent the entry of dust whereas hand oiling, even if the holes are provided with plugs, are likely to permit the entry of some dust. Where grease cannot be used on a bearing a heavy cylinder oil should be employed, because of the temperature and the pressure.

Where the primary gears are belt driven they are generally exposed and the quality of the oil is not so important. Because the pressures here are usually heavy a cylinder oil is better than a light oil, but for spur gears operating at higher speeds a lighter oil is preferable.

As to pulverizers, the author recommends a somewhat heavy oil because the bearings operate at high temperatures, partly because of high speeds and partly because of the highly preheated air. In such cases a compounded oil is of advantage because of its greater oiliness although a straight mineral oil may be more suitable where the temperatures are very high. Grease of a high melting point and of fibrous structure is suggested for vertical roll shaft bearings where the clearances are greater.

On the other hand, where conditions call for a fairly heavy oil when running it may be found better from the point of view of easy starting to fit an oil cooler in the sump; this can be turned on after the machine has started. With this arrangement the bearings will receive oil of the right viscosity when running and will be lubricated properly at the start.

Automatic Feedwater Regulator

Fig. 1 shows the arrangement of the Hannemann feedwater regulator as described in the July 1937 issue of *Die Wärme*. In addition to the water level regulator *a*, there is installed a regulator responsive to pressure which includes a diaphragm *c* that operates the throttle valve *e*. A mercury column *f g* maintains a predetermined pressure beneath diaphragm *g*, which pressure, because of the connection *h* to the steam drum, becomes a constant over-pressure above the boiler steam pressure. Above the diaphragm there is a pressure equal to that within the feed line beyond valve *e*.

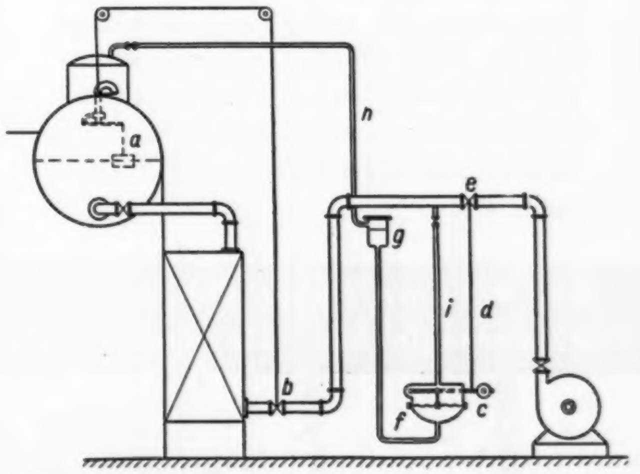
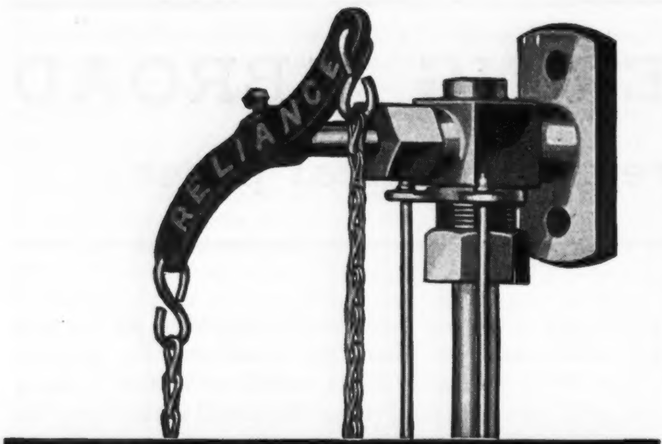


Fig. 1—Diagram of boiler equipped with pump pressure differential and feedwater regulator

The operation and purpose of this arrangement is easily seen. To balance the diaphragm the feed-line pressure must equal the steam pressure plus the over-pressure due to the mercury column. Even with variable boiler pressures this constant over-pressure maintains, assuring a uniform feed and operation of the water-level regulator. In cases, however, in which there is a high tubular resistance to flow in the line to the boiler, as through an economizer, a relatively high over-pressure becomes necessary to overcome the influence of this high resistance. Again, if the boiler load falls sufficiently the



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RELIANCE WATER GAGES

You must know where your boiler water level is—and know it *all the time.* Water gages that go blind for any reason are an intolerable risk. Gages constantly needing repairs are an intolerable nuisance.

Ask the owners of several hundred thousand Reliance Water Gages if it is true that these gages do reduce to a trifling minimum the common troubles of breaking glasses and leaking valves.

Reliance design and materials give you a large bonus of safety and satisfaction through their steady dependability—you'll be glad if you join the huge company of Reliance water gage customers, a list that reads like a Blue Book of American Industry.

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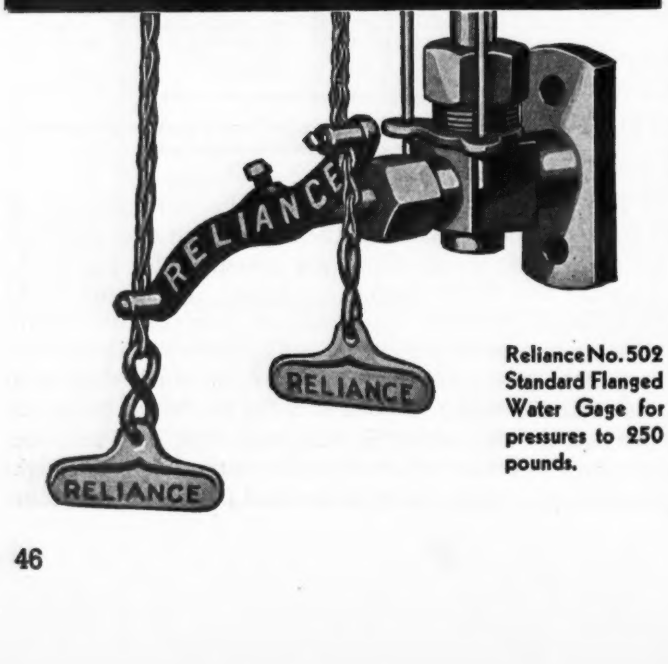

Reliance No. 502 Standard Flanged Water Gage for pressures to 250 pounds.

fixed high over-pressure may be several times that necessary; consequently more water than required for the steam output will flow into the boiler during the load change until the water level regulator throttles this flow because of the rise in water level within the steam drum. Also, the water-level throttle-valve opening becomes too small and may approach the limit where hunting occurs. To overcome such a disadvantage it becomes necessary to provide for regulating the over-pressure in relation to the steam output.

In Fig. 2 is shown a solution of this problem. Throttle *c* provides a uniform pressure leak into the pipe leading from the boiler feed line to the top of the diaphragm

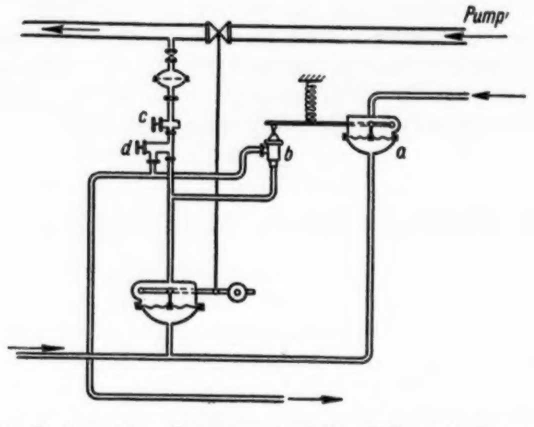

Fig. 2—Automatic adjustment of the differential pressure according to boiler load

which controls the throttle valve in the boiler feed line. The needle valve *b* provides a variable leak in this pipe by which the pressure to the top of the diaphragm may be varied. By opening *b* the pressure drops and the diaphragm rises, thereby opening the boiler feed throttle valve and increasing the feedwater pressure or rate of feed. Valve *b* is controlled by a pressure-differential measuring device *a*, consisting of a diaphragm having boiler pressure below and having on top the pressure taken in the neighborhood of the steam consumer. The greater the steam flow, the greater will be the pressure drop from the boiler to the consumer; hence the pressure difference between the bottom and the top of the diaphragm and the resultant opening of the needle valve *b*. In this manner the feedwater pressure is automatically adjusted to suit the steam output of the boiler.

In order to adapt the control to changes in the total resistance to flow, such as may be caused by adding to or taking boilers off the line, the throttle valve *c* may be manually changed. By way of supplementary adjustment to the automatically controlled valve *b*, or for complete manual control, there is provided a hand valve *d*.

The Hannemann control has been in successful operation since 1935.

Gas Detoxification

Two experimental plants are to be built in Vienna for the detoxification of town gas, says *Fuel in Science and Practice* for September 1937.

The larger of these plants is to employ the Bössner-Marischka process which consists of passing the gas over

a catalyser in the presence of steam in order to remove the carbon monoxide. This combines with water vapor, producing carbon dioxide and hydrogen at temperatures between 350 and 500 C. The catalyst employed is a natural mineral called "ankerite" which contains iron, calcium and magnesium.

The second plant, which is being erected at the Vienna Technical University, will employ a process devised by Professor Müller. As in the other process, carbon monoxide is converted to carbon dioxide by combination with steam in the presence of a catalyst but the carbon dioxide is later removed from the mixture. This second step makes the process somewhat more expensive to operate than the first.

Gas Washing on Ships

"Improvement of passenger deck conditions on luxury liners," says *The Fuel Economist* of August, "has led to the practice of installing gas washing equipment to avoid the discharge of soot and ash above the superstructure."

Wet washers of the centrifugal type are in operation on many British ships such as the Queen Mary, the Empress of Britain, Alcantara, and Asturias.

The wash water together with the entrained solids is discharged overboard by means of a steam jet below the load water line of the ship.

NOW—

A SMALL SIZE FORGED STEEL STEAM TRAP

HERE is good news for power engineers—a forged steel trap by Armstrong priced only a little above ordinary cast steel! Designated as No. 312 (½" or ¾"), this new trap is fully equal in quality to other Armstrong forged steel traps but is priced lower because of smaller size. Especially designed for handling small drip jobs at pressures from 250 to 450 lbs., No. 312 can also be used to an advantage on jobs ranging from 150 to 250 lbs. *with superheat.* Because of low price, it is economical to install one of these traps ahead of every high pressure valve where condensate might accumulate and cause trouble due to cooling of disc. *Write for complete information.*

ARMSTRONG MACHINE WORKS
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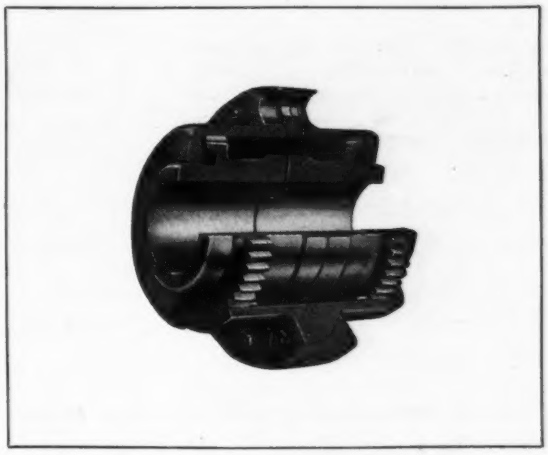
POOLE
Flexible Couplings

ALL METAL • FORGED STEEL
NO WELDED PARTS



The Poole flexible coupling combines great mechanical strength with an unusual capacity for adapting itself to ordinary shaft misalignments. It has no springs---rubber---pins---bushings---die castings or any flexing materials that require frequent replacement.

Using strong specially treated steel forgings, long wearing gears in constant bath of oil, this coupling eliminates your coupling troubles.

OIL TIGHT • FREE END FLOAT
DUST PROOF • FULLY LUBRICATED

***Send for a copy of our* Flexible Coupling Handbook**

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BALTIMORE, MD.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request.

Crushers and Mills

The C. O. Bartlett & Snow Company, Cleveland, O., has issued a new catalog, No. 77, describing its single-roll, two-roll and four-roll crushers, swing-hammer pulverizers, disintegrators, ball mills and various types of feeders. The booklet contains 44 pages of engineering diagrams, capacity tables, illustrations and suggestions for application.

Expansion Joints

Yarnall-Waring Company, Philadelphia, has issued a new 16-page bulletin, EJ-1906, dealing with the Yarway Gun-Pakt slip-type of expansion joint. Its several features are illustrated and fully explained and tables of weights, dimensions and prices are included for both the single- and the double-ended types of joints.

Instruments

A 56-page book on indicating and recording temperature and pressure instruments has just been issued by C. J. Tagliabue Mfg. Co., Brooklyn, N. Y., presenting detailed information on the latest "TAG" developments. Complete data are included on indicating and recording controllers for temperature and pressure, recording thermometers, recording pressure gages and dial-indicating thermometers.

Insulcrete

A light-weight insulating concrete, called "Insulcrete," is described in a new bulletin issued by Quigley Company, New York. This material is of cellular composition and may be used for direct exposure to flame and furnace gases up to 2500 F. It has application for furnace linings, doors, dampers, heat shields and for oil burner combustion chambers as well as for insulating flues, underground conduits for steam pipes, etc.

Liquid Level Controllers

Bulletin No. 2675, issued by Cochrane Corporation, Philadelphia, illustrates and describes the Cochrane Liquid Level Controllers for services in the power and process fields, controlling levels and regulating the flow of liquids to or from surge tanks, storage tanks, receivers, heaters, condensers and evaporator units. A number of models and combination arrangements available for the varied requirements encountered are described, together with tables of dimensions, weights and list prices.

Monel

The Development and Research Division of The International Nickel Company has brought out a revised 16-page bulletin, No. T-9, dealing with the engineering properties of "K" monel, as used for pump shafts in marine service, pump sleeves, trim for valves, balls for check valves, etc. The composition, physical properties and corrosion resistance are discussed and data are given on heat treatment and shop working.

Pumps

Fairbanks, Morse & Co., Chicago, has brought out three new bulletins, one dealing with its line of duplex steam pumps and the other two with deep-well turbine pumps, having oil lubrication and water lubrication. The duplex pumps are for boiler feed and general service in capacities up to 464 gallons per minute and fluid pressures up to 420 lb. Tables are included giving dimensions and specifications.

Refractory Cement

Refractory & Insulation Corporation, New York, has issued Bulletin R-31 on its No. 3000 refractory cement applicable to setting brickwork and the repair of refractory parts of boiler furnaces, industrial furnaces, coke ovens and other high temperature processing equipment. The fusion point of this product is slightly above 3000 F.

Relief Valves

A 16-page bulletin, No. 2710, has been issued by the Cochrane Corporation, Philadelphia, describing its line of multiported relief valves. These valves employ a multiplicity of valve disks and are applicable for back-pressure, atmospheric-relief or check-valve service for steam, water, air or gas. Specifications of styles and dimensions for various services are covered and the tables include weights and list prices.

Switchgear

A pictorial guide to modern switchgear is contained in an 18-page booklet recently issued by the General Electric Company. Over 120 different designs of equipment, such as air circuit breakers, oil circuit breakers, indoor and outdoor power switching equipment, relays, switches, etc., are illustrated and briefly described. In connection with each is a key reference to the individual bulletin describing in detail the particular apparatus. In other words, the booklet is intended as a convenient reference for the selection of individual switching items.

Valves

A new bulletin, issued by Walworth Company, New York, deals with its new "500 Brinell" globe valves in sizes up to 2 in. for 350 lb pressure. The bulletin also discusses the testing of metals at elevated temperatures and contains a pictorial section showing various steps in the making of Walworth valves.

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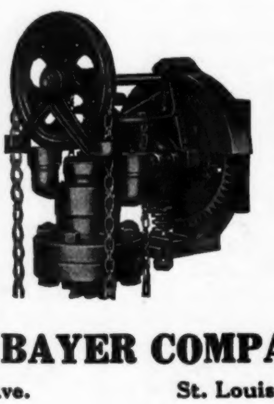

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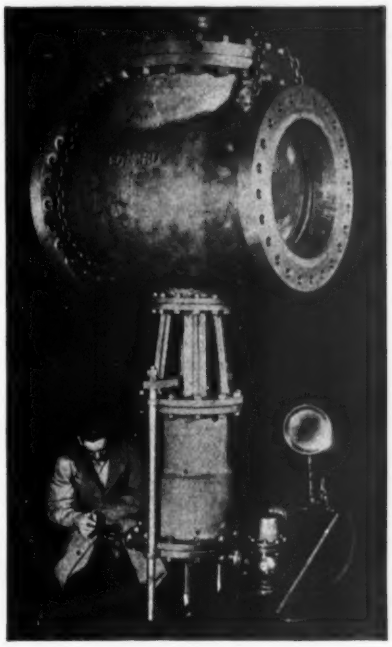
NEW EQUIPMENT

Bleeder Valve

The Edward Valve & Mfg. Co., Inc., East Chicago, Indiana, has recently enlarged its line of bleeder non-return valves. The illustration shows a 24-in. oil-operated swing check valve, for 200-lb steam service pressure. The valve acts as a freely operating swing check valve, or it may be closed automatically by oil pressure release through the 2-in. pilot valve shown



in the lower right-hand corner. The gage and flexible hose line shown in the picture were used in connection with the operating test at the shop. The seating faces of seat and disk are Stellited and the seat is welded into the valve body. The assembled valve shown weighs nearly three tons.

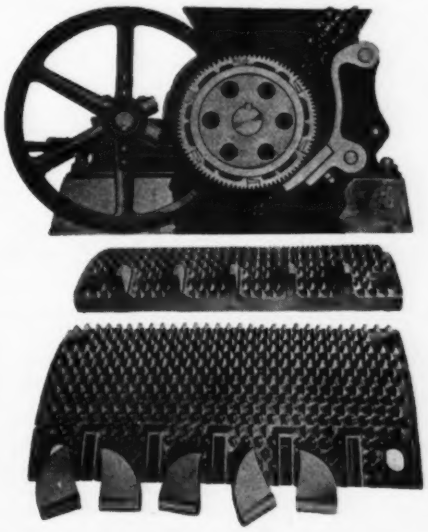
Boiler Tube Emergency Plugs

A simple emergency plug that can be inserted in the tube without drawing the fire is being put out by the Hardie Made-Rite Boiler Tube Plug Co., New York. It consists of a center tapered wedge over which slips, in order, a three-part expanding ring, normally held shut by a circular spring, a thick malleable iron washer, an asbestos composition ring and a tightening nut. The plug thus assembled is placed

in the tube end and the nut tightened with a small hand wrench. This pulls the tapered wedge through the expanding ring thereby locking against the tube wall and preventing the plug from turning. At the same time it expands the asbestos composition ring against the tube wall and seals the tube. To handle leaks between tube and sheet, the asbestos ring is replaced with another steel ring and the unit is placed in the tube only far enough so that the expanding ring spreads the tube as much as is necessary. It is easily removed and can be used over again. Similar units for marine boilers are assembled on a rod. By tightening the nut on the front header the far end of the tube and the front of the tube are both sealed at the same time, without access to the back of the boiler. The plug is made for water tube boilers, as well as for fire tube, and has been tested at a pressure of 800 lb per sq in. It is made of certified malleable iron.

Coal Crusher

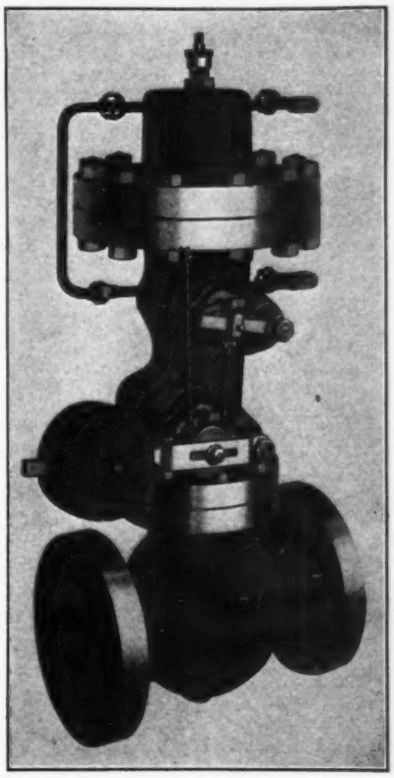
A new single-roll crusher specially designed for the preparation of stoker and smaller size coal with a minimum of degradation and oversize is announced by the Jeffrey Manufacturing Co., Columbus, Ohio. Its renewable segments carry thin, sharp pyramid and spear-point teeth, also insertable "Wejtite" feeder teeth for use where reduction of large coal is required. These teeth, together with the pattern of their spacing, minimize degradation by causing a piercing action



rather than a mashing action. A new breaker plate design eliminates boiling of the feed and therefore increases the capacity. An extended shoe carries the business zone farther along the roll to minimize oversize. These new features are also obtainable in replacement parts for change-over of earlier type Jeffrey single-roll crushers.

Feedwater Regulator

A new two-element steam-flow type of boiler feedwater regulator, known as the Copes "Flowmatic" regulator, has been introduced by Northern Equipment Company, Erie, Pa. It was designed to meet the demands for more accurate feedwater control on mōdern high rating boilers and on other units subjected to rapid and wide load fluctuations. It feeds the boiler according to the rate of steam flow and



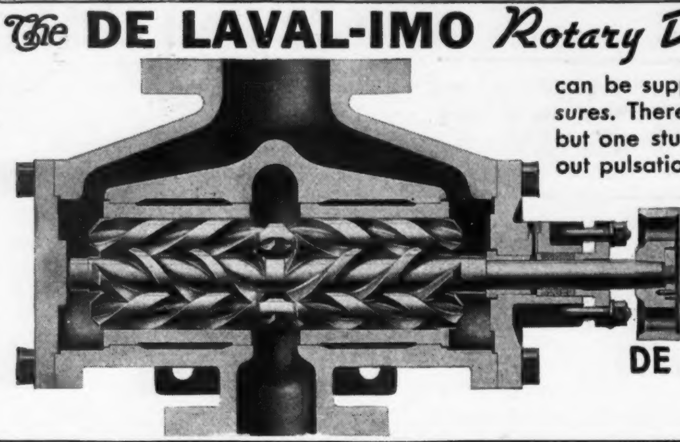
provides the water level characteristics that give best operating results on the individual unit. A higher water level can be provided on heavy loads than on light, or a practically constant level can be maintained for all ratings.

It has two control elements. The steam flow controller measures the rate of steam flow by taking the pressure drop through the superheater, and the water level thermostat, with tension-type expansion tube as used in the standard Copes regulator for many years, responds instantly to changes in the boiler water level. These two control elements are connected mechanically to the feedwater control valve in such a way that the valve is positioned by the resultant of the two forces.

The feed control valve may be directly operated or hydraulically operated, depending on the service conditions, and it may be installed at any position in the boiler feed line. It can be equipped with a motor operator permitting repositioning of the valve by push button from the operating panel.

This regulator is furnished in all pressure standards from the 250 lb upward, and valves are furnished in 2- to 6-in. sizes, inclusive.

The DE LAVAL-IMO *Rotary Displacement* OIL PUMPS



can be supplied for *pumping oil in all capacities and pressures.* There are no pilot gears nor separate bearings, and but one stuffing box. The discharge is continuous and without pulsation, and no valves are required.

The pump can be coupled directly to an electric motor or a steam turbine, or to a shaft of any machine to which lubrication is supplied.

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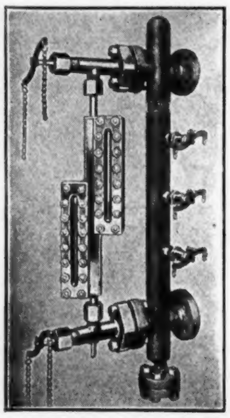

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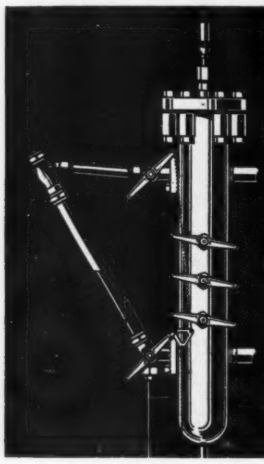

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